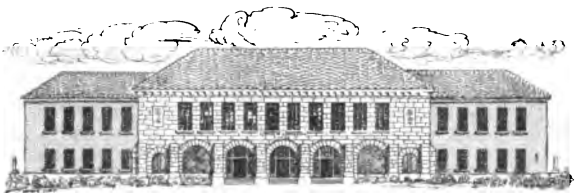
ELEMENTS OF GENERAL SCIENCE

LABORATORY PROBLEMS

CALDWELL-EIKENBERRY-GLENN



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PREFACE

The development of courses in general science, and their extensive adoption in high schools, has been the most important change in science teaching during the past two decades. In teaching this subject high-school teachers have found it more difficult to secure adequate help in their laboratory, demonstration, and field work than has been true in connection with the text material. While the outline for experimental work requires recognition of the variations in methods and materials used in different schools, it must also be sufficiently specific and comprehensive to serve adequately as a guide to the pupils. This manual has been prepared in order to meet these needs. It uses most of the topics which appear in Caldwell and Eikenberry's "A Laboratory Manual for General Science," but has organized these topics differently and has added to them. The following are special features of this manual:

A preliminary paragraph with each problem, giving briefly the setting of the problem so that the pupil begins his work with a measure of appreciation of its significance.

Diagrams, sketches, or halftones, as parts of most of the problems, are designed to give suggestions as to setting up apparatus, thus helping to make certain that the experiment is properly performed and at the same time stimulating pupils to invent ways of their own for doing things. In case of most of the illustrations no legends are given, since the directions provide all needed suggestions for proper use of the figures. In a few cases legends are added, but usually the pupil will profit most by use of an illustration as a means of experimentation if a detailed explanation of its significance is omitted.

Clear statements are made of methods of procedure. Type questions of the kinds which should be discussed in each problem

are given under a separate heading. Specific references to text reading are cited in connection with each problem. Definite suggestions are given for the records which are to be made. Notebooks have often been made too burdensome with endless and sometimes meaningless note writing, whereas brief notes with correct diagrams are better. Occasionally a more extended written report is called for in order to lead the pupil to the proper use of a clear and full account of an occurrence.

Common materials are used for experimentation, since simple phenomena relating to common problems are likely to be more educative for young pupils than those which are uncommon and complex. The materials needed are listed in each exercise. It is hoped that teachers will encourage pupils to use their own initiative in devising new ways to perform the experiments, as well as in working out additional problems and projects which are suggested.

Optional problems provide extra work for pupils who work especially rapidly or who wish to use added time for the course.

THE AUTHORS

CONTENTS

SUGGESTIONS CONCERNING EXPERIMENTAL WORK

Each observant person is constantly noting occurrences in nature which he would like to have explained to him. A flying kite leads us to ask how it is made to fly. Boiling water in a kettle lifts the lid which covers it, and we want to know what causes the lid to rise. The tender stem of a plant pushes up through gravelly or hard-packed soil, crowding the pebbles and soil out of the way, and we ask how the delicate shoot, still uninjured, can move such solid bodies. A colony of ants makes its home in a field of corn; the corn is soon retarded in its growth, and we want to know what is taking place. A pupil visits a friend who is ill, and later the visitor may have the same disease as that which affects the friend. What has occurred? Many such questions concern our daily lives, and we are more intelligent and more efficient persons when we can answer some of these questions correctly.

There are two good ways of securing answers to our questions. One way is to ask persons who know about these matters or to read what they may have written. The other way is to study the occurrence by means of observation and experiment, thus trying to make the occurrence itself help to answer the question regarding it. It is the purpose of these outlines to use the latter method in answering some important questions.

To secure the greatest good from an experiment it is necessary (1) to watch the way in which the experiment is performed; (2) to select the facts shown by the experiment; and (3) to explain these facts, if an explanation can be made. When you have performed an experiment and discussed it, write your final statement as if your notes were intended to be read by a person who knows nothing about the experiment. In all cases make sure that your work is brief, neat, and clear in its presentation of the facts.

ELEMENTS OF GENERAL SCIENCE

LABORATORY PROBLEMS

PROBLEM 1

AIR AS A MATERIAL (I–1)[1]

The problem. Most of the time we are quite unconscious of the air; in fact, we usually ignore its existence. The condition of the air is a matter of importance to all. It determines whether our sports shall be tennis, golf, and baseball, or coasting and snowballing; it decides whether we shall swim or skate; it affects the kind of clothing we shall wear, the food we shall eat, and the social activities in which we shall engage. It levies a tax for coal at one time and for ice and electric fans at another. How can we find out if air is a real material which we can readily recognize?

What to use. Ring stand, clamp, glass cylinder of about one quart capacity, two-hole rubber stopper, wooden rod, glass tube two feet long, glass plug made from ordinary glass tubing,[2] and the upper half of an eight-inch test tube.

What to do. **1.** Assemble the apparatus as shown in figure 1.

[1] Throughout the manual the problems are numbered serially. Immediately following the title of a problem two numbers appear in brackets. The first of these figures indicates the chapter in the text to which the materials of the problem relate, and the second figure indicates the number of the problem which relates to that chapter. For example, following the title of problem 32 are the numbers (XI–1), which means that this is the first problem relating to the materials of Chapter XI.

[2] In appendix, p. 177, directions are given for work with glass tubing.

2. Hold the open end of the test tube downward and press it slowly to the bottom of the water in the cylinder. Notice the level of the water inside of the tube.

3. Slowly raise the mouth of the tube to the level of the water.

4. Repeat 2, but release the rod when the tube is at the bottom of the cylinder.

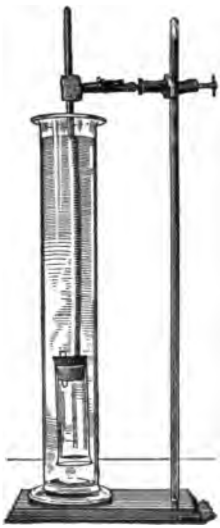


FIG. 1

5. Substitute a glass tube for the wooden rod and repeat 2 and 3 while holding the finger on the end of the glass tube.

6. Repeat 4, using a glass tube instead of the wooden rod.

7. Answer the questions in the following paragraph.

Questions. How high in the test tube does the water rise? Does this vary at different depths? What fact is shown here? What fact is shown in 4? Describe the changes which occur in 6. What conclusions regarding the air does this experiment enable you to make?

Suggestions for report. After a class discussion of the answers to the questions given above, write a correct statement for each question.

Reference work. Make a list of all the illustrations of which you can think to show that air is a material and that it occupies space. Read sections 1 to 5 of "Elements of General Science" (Revised Edition) by Caldwell and Eikenberry.[1]

Optional problems. By means of the apparatus shown in figure 1, and a piece of rubber tubing to fit the glass tube, show how a diving bell works.

[1] All text citations throughout this manual are to the text here cited, and the name of the text will not be repeated in further citations.

PROBLEM 2

THE ACTION OF COMPRESSED AIR (I–2)

The problem. The extensive use of compressed air is one of the interesting developments of modern civilization. The automobile tire, football, bicycle tire, passenger train, street car, interurban car, subway car, freight car, rock drill, dentist's drill, thermostat, doorstop, and many other devices utilize compressed air in some way. What qualities of compressed air make it so useful in these appliances?

FIG. 2

What to use. Wide-mouth bottle with two-hole rubber stopper to fit, glass plug for one hole, jet tube six inches long, glass tube six inches long, two inches of rubber tubing, clamp, and water.

What to do. 1. Assemble the apparatus as shown in figure 2. Prepare the jet tube as suggested in the appendix.

2. Open the clamp and blow into the bottle as much air as possible. While blowing, close the tube with the clamp, then remove the tube from the mouth.

3. Tip the mouth of the bottle away from you and open the clamp. Repeat 2 and 3 until all of the essential facts have been observed.

4. Answer the questions in the following paragraph.

Questions. Why do bubbles appear as you blow into the bottle? Why is the tube closed before it is removed from the mouth? What drives the water out of the bottle? Why is all of the water not driven out? Why does water remain in the upper part of the tube? How is it possible to get so much air into the bottle?

Suggestions for report. After a class discussion of the answers, they should be revised and recorded in correct form.

Reference work. Explain how one important fact shown by the experiment is used in any compressed-air appliance. Make a list

of all the uses of compressed air that you have seen. By means of a diagram similar to figure 3 of the text, explain the action of a bicycle pump.

Optional problems. The chemist makes a wash bottle for forcing distilled water against glassware, etc. Can you devise one with this apparatus, using it and an extra piece of glass tubing? Make a study of the doorstop or other air appliance and explain its action.

PROBLEM 3

SOME USES OF THE VACUUM (I-3)

The problem. No less interesting than the employment of compressed air are the uses made of a chamber from which a part or all of the air has been removed, commonly called a vacuum. The vacuum is utilized in incandescent electric lamps, cleaners for the household and street, mercury barometers, thermos bottles, thermometers, X-ray tubes, and wireless telegraph and telephone instruments.

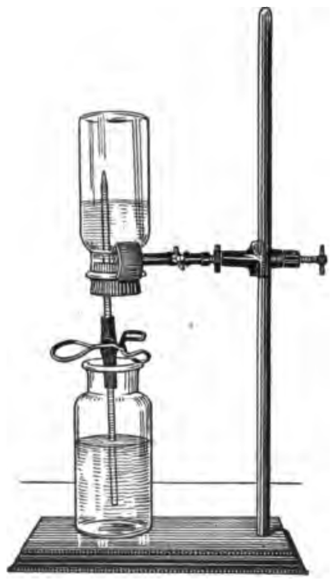


FIG. 3

What to use. Two wide-mouth bottles, pinchcock, two inches of rubber tubing, two-hole rubber stopper to fit the bottle, glass plug for one hole, jet tube, glass tube, and water. A ring stand and burette clamp can be used if available.

What to do. 1. Assemble the apparatus as shown in figure 3.

2. Suck out as much air as possible from the upper bottle, which is empty at the beginning of the experiment; close the pinchcock, quickly place the glass tube under water, and open the pinchcock. Repeat until you have removed from the upper bottle as much of the air as you can.

3. Answer the questions in the following paragraph.

Questions. Why does the water move when the pinchcock is released? Will the apparatus operate without the jet tube? How much water enters the bottle? Why? How much air was removed?

How is this fountain different from that shown in the preceding experiment? What are the chief facts shown by this experiment?

Suggestions for report. Make a cross-section drawing, one-fourth size, of the apparatus used. Name the parts. Write a paragraph which describes the action of the fountain.

Reference work. Make a list of all the uses of a vacuum that you have seen. Explain how the pump shown in figure 3 of the text can be used as a vacuum pump.

Optional problems. Pinch off the tip of a lamp bulb while it is under water. Make a full-size sectional drawing and explain the action of the apparatus.

PROBLEM 4

THE WEIGHT OF AIR (I–4)

The problem. From the preceding exercises we have learned that air is a substance that fills space. Other familiar substances that fill space — as wood, water, and iron — have weight, and it is natural to question whether air may not likewise have weight. On the other hand, we are living at the bottom of a great ocean of air, but we are not conscious of any weight due to its pressure upon us, and this might lead us to believe that air does not have weight. Which of these suppositions is correct?

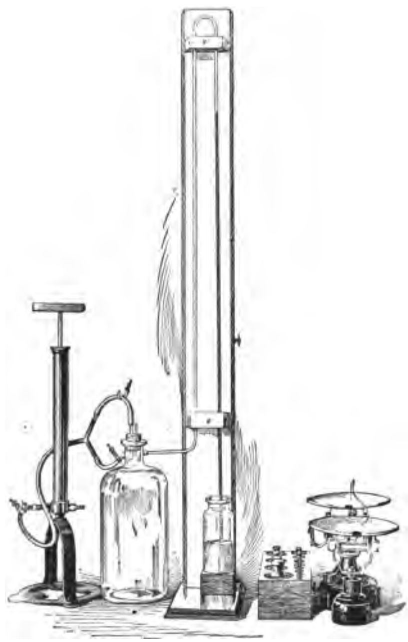


FIG. 4

What to use. Large flask or large bottle of one-half gallon capacity or more, one-hole rubber stopper, Y-tube, five feet of extra strong three-sixteenths-inch rubber tubing, three clamps, pump (filter pump may be used), five feet of three-sixteenths-inch glass tubing, meter stick, ring stand, wire, mercury, scales, and set of weights.

What to do. **1.** Study the metric system given in the appendix to learn what is meant by meter, centimeter, liter, cubic centimeter, kilogram, and gram.

2. Assemble apparatus as in figure 4.

3. Weigh carefully the bottle after it is tightly closed and record the weight.

4. Pump air from the bottle until it seems probable that no more will be removed. Close the clamp next to the pump and watch the mercury gauge to see if the connections leak. Vaseline may often be used to advantage where a glass tube joins a rubber tube. If there is no leak close the clamp next to the bottle. Remove the bottle, weigh, and record the weight. Measure the height of the mercury.

5. Answer the questions in the following paragraph.

Questions. What are the English equivalents of the meter, liter, and kilogram? What is the proper method for weighing? What occurs in the bottle of mercury? Why? Why is the change rapid at first? Why does the mercury column change when the clamp is released? Does the bottle change in weight? Why? What does the mercury column show?

Suggestions for report. After a class discussion of the answers, write them in correct form in the notebook. Write answers to Questions 13, 14, 15, and 22 in section 2 of the text.

Optional problems. Determine whether all the air was exhausted from the bottle by putting the neck under water before opening the clamp. Does this result agree with the readings on the gauge? About what fraction of the air was exhausted? Measure the size of the bottle and compute its volume in cubic centimeters, or measure its volume by means of water and a measuring glass. Knowing the volume of the air contained in the bottle and the weight of the air, calculate the weight of air per thousand cubic centimeters. Make the proper correction for the error due to the air not pumped out. How does your result compare with the weight given in the text? Find the English equivalents of gram and centimeter and express your results in ounces and inches. Make a diagram of a vacuum cleaner to show how the air moves. By means of a bell jar, rubber stopper, rubber balloon, glass tube, and pan of water make a model of the human lungs.

PROBLEM 5

THE MERCURY BAROMETER (I–5)

The problem. It is important to know the air pressure when ascending mountains or making flights in balloons or airplanes, when working under water or operating submarines, and in many manufacturing operations. We found it convenient to use a gauge for measuring air pressure in Problem 4. The task of devising a convenient instrument for measuring air pressure was solved long ago by the invention of the barometer. How is this instrument constructed and how does it operate?

FIG. 5

What to use. Ring stand, one ring, clamp, short glass tube, meter stick, two pounds of mercury, beaker, small funnel made from a four-inch test tube, glass tube three sixteenths of an inch in diameter and forty inches long and sealed at one end, two-hole rubber stopper, wide-mouth bottle, beeswax or paraffin, and rubber tubing.

What to do. 1. Place the rubber stopper on the glass tube as in figure 5. Fill the glass tube with mercury. The mercury should be poured slowly through the small funnel until the tube is filled. A bottle which has a layer of beeswax or paraffin one-half inch thick on the bottom should be inverted over the tube and pressed down firmly. Invert the tube and immediately pour some mercury into the bottle. Lift the glass tube slightly and then make secure with the stopper. Assemble the apparatus as in figure 5.

2. Measure the vertical distance from the mercury level in the basin to the level in the tube. Tilt the tube and measure the vertical distance again.

3. Remove some air from the bottle with the mouth. Blow into the bottle.

4. Answer the questions in the following paragraph.

Questions. What is the height of the mercury column? How does tilting the tube affect the vertical height? What holds the mercury column in place? What happens when the air is removed? Why? What occurs when air is blown into the bottle? Why? What pressure change can you cause by suction? by blowing? Summarize the conclusions from this experiment.

Suggestions for report. After discussing the experiment write correct answers to the questions given above.

Reference work. Read sections 7 to 11. Explain the operation of a pocket aneroid barometer. How is a standard barometer made? a barograph? Look up the history of the invention of the barometer and prepare a report for the class.

Optional problems. With a thistle tube and a sheet of rubber show that the air pressure is the same in all directions at any one point.

PROBLEM 6

EFFECTS PRODUCED BY CHANGING THE TEMPERATURE OF AIR (I–6)

The problem. Many familiar occurrences depend upon the changing temperature of the air. It is commonly supposed that the impure air in a room is heavy and that it sinks to the floor. Also, it is commonly though wrongly supposed that damp air is heavier than dry air. It is often noted that corn or other crops are frosted first in the valley, indicating that the temperature is lower than on the hillside. The operation of the hot-air furnace also depends upon air temperatures. It is found that milk kept in a refrigerator at 60° F. will develop about fifteen times as many bacteria in one day as milk at a temperature of 50° F. Hence it is extremely important to know where to find the coldest part of the food chamber. How does air behave when cooled or heated?

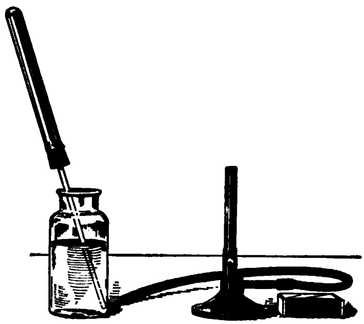


Fig. 6

What to use. Wide-mouth bottle, test tube, one-hole rubber stopper, glass tube one foot long, Bunsen burner with rubber tube, matches, and water.

What to do. **1.** Assemble the apparatus as shown in figure 6.

2. Place the glass tube about one-fourth of an inch under water, and warm the test tube with both hands.

3. The Bunsen burner, which is to be used as a source of heat in the laboratory, consists of four parts: a mixing chamber, an air regulator, a base, and a gas tube. Carefully unscrew the tube and examine the burner. Note the use of the parts mentioned

and assemble the burner with care. To light the Bunsen burner, turn on the gas, then bring a burning match to the top of the burner. Turn the gas cock until the flame is about four inches high. Adjust the air regulator until a blue flame with a slight greenish cone is obtained. Always use the blue flame instead of the yellow flame unless otherwise directed.

4. Warm the test tube slowly and uniformly with the Bunsen flame, turning the tube slowly as you heat it.

Questions. What occurs when the hands are placed on the test tube? Why? What occurs when the hands are removed? Why? Why is one part of the burner called a mixing chamber? Explain the purpose of the air regulator. What makes the flame yellow when the air regulator is closed? What is the green cone in the flame? Is it hot? How do the results in 2 differ from 4? Why?

Suggestions for report. Make a cross-section diagram of the apparatus used. Write a complete account of the experiment according to the suggestions given on page 1.[1]

Reference work. Read sections 12, 14, and 15. Automobile tires sometimes burst while standing in the sun. Explain. How do you account for the upward currents of air near a stove, lamp, or radiator? Why does smoke go up a chimney? How is a gas stove like a Bunsen burner?

Optional problems. Can you make an "air thermometer" with a test tube, a one-hole rubber stopper, a glass tube eighteen inches long, and a Bunsen burner? Can you make a Bunsen burner with a No. 1 cork and six inches of glass tube, a set of cork borers, and a Bunsen flame? Can you devise a new experiment to show that air expands when heated?

[1] On page viii there is given an outline for a completely written report. It is not thought necessary to have all reports as fully written as there indicated, but some should be so written in order to develop the habit of complete description.

PROBLEM 7

VENTILATION (I-7)

The problem. It is estimated that a man exhales six cubic feet of carbon dioxide per hour. A gas light may produce 3.75 cubic feet of this gas in the same time. As carbon dioxide is produced oxygen is consumed. In order to have an ample supply of oxygen some circulation of air must be obtained. These and additional facts make it necessary to ventilate the rooms of buildings. The usual method is to open one or more windows. Should these be open at the top or at the bottom, or both? If more than one window is opened should they be on the same side of the room?

What to use. Box as shown in figure 7, candle, punk or touch paper (soak filter paper in a solution of potassium nitrate and dry).

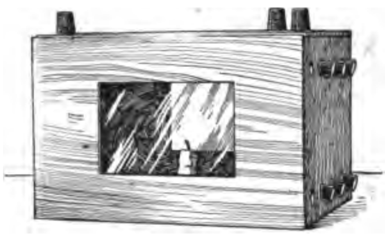


FIG. 7

What to do. **1.** Arrange the apparatus as shown in figure 7. Close all the holes. Light the candle and place it in the box. Watch the flame carefully for several minutes.

2. With the candle lighted as before remove one of the stoppers. Try different arrangements of openings until you find the smallest number of openings with which you can secure a large flame.

3. Trace the course of the air into and out of the openings by holding a smoking object near the holes. Make a diagram showing the path of the currents.

4. Arrange the box to represent your room. Place the candle in the position occupied by your bed. Secure the best ventilation possible and then draw a diagram showing the air currents.

Questions. How does the candle flame resemble the Bunsen burner? Does the candle burn continually in the box? Why?

What is the course of the air currents? What arrangement did you have for 2? for 3? for 4? Summarize the chief facts shown by the experiment.

Suggestions for report. Correct answers to the questions above should be recorded in the notebook.

Reference work. Read sections 15 to 18. Make a diagram of your room at home, showing the heating and ventilating system (see Fig. 15 of the text). Show the points of likeness and difference between figures 15 and 18 of the text.

Optional problems. Can you determine the course of the air currents about a Bunsen burner? a lamp? a gas stove? an open door? an open window?

PROBLEM 8

HOT-WATER HEATING SYSTEMS (I-8)

The problem. It is a common observation that when water is to be heated, the heat is always applied to the bottom of the vessel. Is there a reason other than convenience for this practice? Certain types of hot-water heaters have a short pipe arranged in the fire box of the stove. How is it possible to heat a large quantity of water by this arrangement when the water tank is far removed from the furnace or stove? In the hot-water heating system the furnace is placed in the basement. How is the water made to circulate to the various rooms? These and other similar questions can be answered if we know how water behaves when heated.

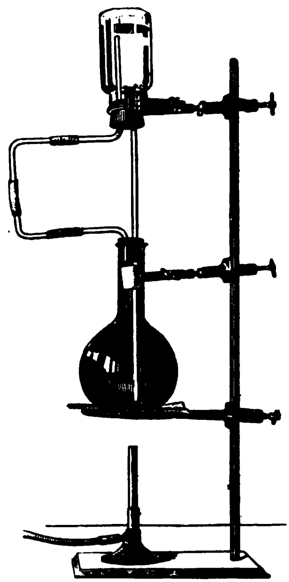


FIG. 8

What to use. Ring stand, large ring, wire gauze, two burette clamps, flask (500 cc.) with two-hole stopper to fit, wide-mouth bottle (bottom removed) with two-hole stopper, four feet of glass tubing, six inches of rubber tubing, and black ink.

What to do. 1. Assemble the apparatus as shown in figure 8. No air bubbles should be allowed between the stopper and the liquid in the lower flask. Fill the bottle with clear water after the apparatus has been assembled.

2. Warm the water in the flask slowly and watch for results. If the glass tubes are filled with air bubbles the action may be delayed.

Questions. Does the outside of the flask change in appearance when the burner is lighted? Why is the bottom of the wide-mouth

bottle removed? Describe the changes produced by heating the colored water. Explain why these changes occur. Does this experiment show why a teakettle is heated at the bottom? Summarize the essential facts shown by the experiment.

Suggestions for report. Make a cross-section diagram of the apparatus used. Indicate the circulation of water by arrows and brief notes.

Reference work. Show all the points of likeness and difference between the water heater (figure 16 of the text) and figure 8. Prepare a diagram of the heating system in your home. See figures 15 and 121 of the text for suggestions.

Optional problems. Can you show the convection currents in a beaker of water by means of sawdust? How does the cooling system of an automobile work?

PROBLEM 9

TEMPERATURE JUDGMENT (I–9)

The problem. The oldest and most common way of estimating temperature is to note whether a thing "feels" cold or warm. That this may not be an accurate and satisfactory way of measuring temperatures is suggested by the fact that persons often disagree regarding the temperature of an object. The fact that a rug feels warmer than a bare floor, although at the same temperature, suggests that the body is not a very satisfactory standard. The

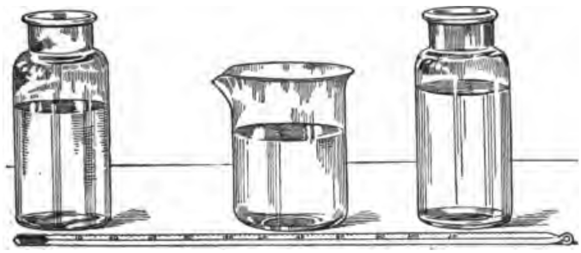


FIG. 9

words "temperature" and "heat" are often confused. Temperature is a condition of objects which can be measured by means of thermometers. On the other hand, a certain amount of heat must be furnished to an object to warm it from one temperature to another.

What to use. Thermometers, both centigrade and Fahrenheit, beaker of lukewarm water, ice, wide-mouth bottle filled with hot water, and wide-mouth bottle filled with cold water.

What to do. **1.** Assemble the apparatus as shown in figure 9.

2. Put the right forefinger in the cold water and the left forefinger in the hot water. Let the fingers remain in the water a short time, then remove both and place them at once in the beaker of lukewarm water.

3. Next examine the thermometer. What is the highest temperature that can be recorded on each scale? the lowest? How many degrees does the smallest division represent on each scale?

4. Place the thermometer in the cold water. Read the temperature without removing it. Record the temperature in the table below. Record the temperatures of the warm water and hot water. Record the temperature of the room and that obtained by placing the thermometer under the tongue.

Questions. Describe the sensation produced on the two fingers by the lukewarm water. What is the lowest temperature that can be read on each scale? Why is there a bulb on the instrument? What metals and liquids behave as mercury when heated? What mistakes may one make in reading a thermometer?

Suggestions for report. Record the readings in this table:

TEMPERATURE OF	FAHRENHEIT	CENTIGRADE

Reference work. Read sections 13 and 14. Show how to change centigrade readings into Fahrenheit and vice versa.

PROBLEM 10

GRAPHICAL COMPARISON OF THERMOMETER SCALES (I-10)

The problem. Since our senses are unreliable in making exact estimates of the temperatures of objects, special instruments have been devised. Several kinds of thermometers are in use. The principal differences are with reference to the scales with which they are provided. In America the Fahrenheit scale is commonly used in the home. In all science work the centigrade scale is found most convenient. What is the relation between these scales?

What to use. Rule, cross-section paper, readings from the previous experiment, and a sharp pencil.

What to do. **1.** Prepare a graph to change readings from one scale to another as follows: On the cross-section paper (p. 28) place a small dot with a small circle around it at the intersection of the lines for 0° C. and 32° F. Place a similar dot at the intersection of the lines for 100° C. and 212° F.

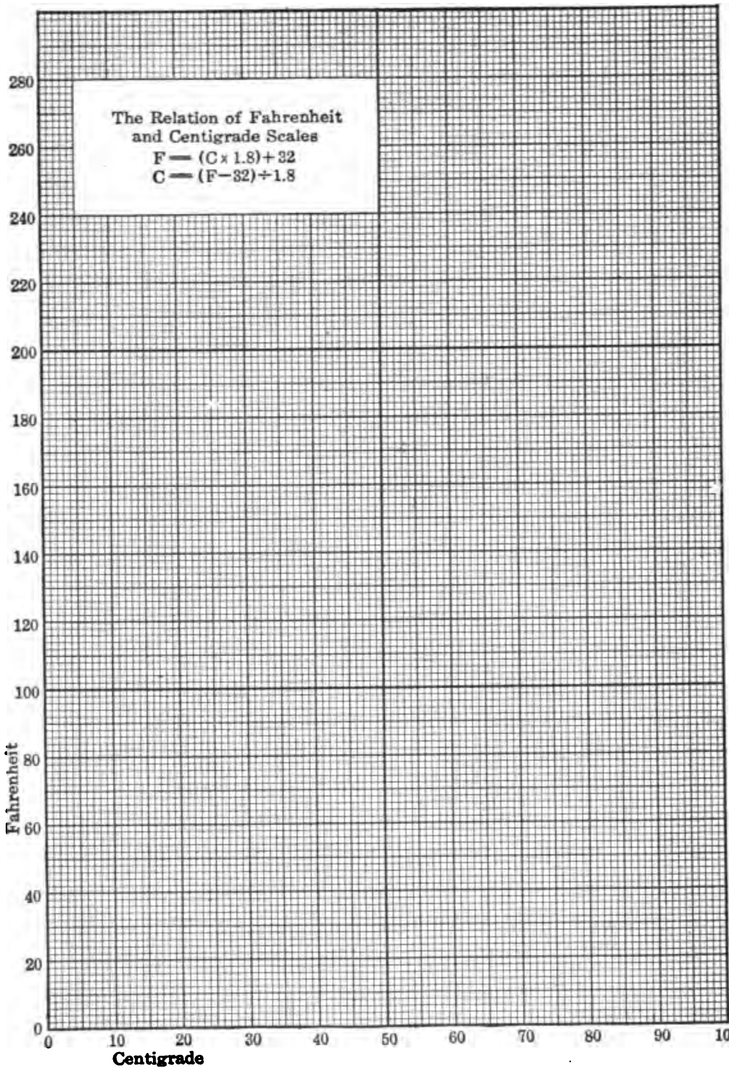
2. Draw a fine straight line (using a ruler) across the page connecting these two points.

3. By means of this line find what temperatures correspond to 68° F. and 30° C. Check your results by the methods given at the top of the page of cross-section paper.

Questions. Which thermometer scale is most convenient? Why? How could the graph be changed so that it would show fractions of a degree?

Reference work. Make a list of the different kinds of thermometers that you have seen in use. Make a neat drawing of one of them. What can you find about the history of the Fahrenheit thermometer? the centigrade thermometer?

Optional problem. Can you make a model thermometer?



The Relation of Fahrenheit
and Centigrade Scales
F = (C × 1.8) + 32
C = (F − 32) ÷ 1.8
Fahrenheit
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Centigrade

PROBLEM 11

HUMIDITY AND HEALTH (II-1)

The problem. The necessity for reliable information about the moisture of the air arises from the fact that this moisture affects health, the drying out of wood and furniture, and the behavior of cloth etc. A damp basement often contributes to the rapid formation of rust and mold. It is probable that the dry air of heated houses is injurious to health. The water vapor actually present in a cubic meter of air is called the absolute humidity. This space may or may not contain all the vapor possible at this temperature.

FIG. 10

If the temperature is sufficiently low, part of the moisture will condense. Relative humidity should vary from 40 to 70 per cent in houses. What is the relative humidity in this room? By relative humidity we mean the percentage of saturation at the given temperature.

What to use. Small baking-powder can, thermometer, ice, beaker or cup, reference table (page 25 of the text) water, salt, and dry towel.

What to do. 1. Assemble the apparatus as shown in figure 10. Fill the can to a depth of about two inches with water. Note the temperature of the room and record in the table below. Put some ice in the water and stir slowly, noting the outside of the can closely for any change. Note the temperature of the water the

instant this change appears. Be careful not to break the bulb of the thermometer. Do not allow the moisture from the breath to deposit on the can. If no results are secured when the water is near 0° C. (32° F.) add salt to the water and repeat the process.

2. Dry the outside of the can with a towel and repeat 1. Record all the data in the table below and make the calculations suggested. Refer to page 24 of the text for suggestions.

Questions. What was the room temperature? At what temperature did the moisture appear? Why is it best to stir the water?

Suggestions for report. The readings should be recorded as follows:

ROOM TEMPERATURE		TEMPERATURE AT WHICH MOISTURE APPEARS		
Temperature	Grams of water vapor possible per cubic meter	Temperature	Grams of water vapor present per cubic meter	REL. HUM. $= \dfrac{\text{Grams of water vapor present per cubic meter}}{\text{Grams of water vapor that a cubic meter can hold}}$

As the values are obtained they should be placed upon the blackboard. Take the average as the probable humidity.

Reference work. Read Chapter II of the text.

Optional problem. Refer to the *Scientific American*, Vol. 115 (September 16, 1916), p. 264, for various forms of hygrometers. Can you make one of these?

PROBLEM 12

CAUSES OF VARIATION IN ATMOSPHERIC TEMPERATURE (III-1)

The problem. The change of temperature that comes with the seasons is to many of us the most striking difference between the seasons. Why should there be any difference in temperature? Is the sun giving off as much heat as before? Are we farther away from the sun? Why should it make any difference in the heat received by the earth whether the sun is high up in the heavens or lower down near the horizon?

What to use. Piece of cardboard twelve inches square, tacks, string, and yardstick.

What to do. 1. This experiment should be started a week or more before the date of final observation and discussion. Place a large piece of cardboard with a hole three eighths of an inch in diameter in the upper part of a south window and fasten it securely. Notice the spot of sunlight on the floor at 9 A.M., 12 M., and 3 P.M. Trace these positions of the spot on the floor and record the date.

2. Note the position of the spot at these hours a week or more later. Note the date and record the positions as before.

Questions. What variations are there in the spot on the floor at different times? When is it smallest? largest? Is there a relation between the area covered by the sunlight and the temperature produced? Is the spot the same distance from the window at 12 o'clock on successive days? What does this indicate about the sun's position at noon at different times of the year? Why does the sun have these positions?

Suggestions for report. Make a drawing showing the conditions on the different dates. Correct answers for the questions above should be written in the notebook.

Reference work. Read Chapter III of the text. Write answers to the questions given on page 32 of the text.

Optional problems. Can you design and construct a simple piece of apparatus by means of which to show the area covered by a beam of light which is a square inch in cross section as it strikes a level surface at 9 A.M., 12 M., and 3 P.M.?

PROBLEM 13

WEATHER OBSERVATIONS (IV-1)

The problem. Observations of the weather began early in the development of intelligence in the human race, and the importance of weather predictions was early recognized. The later invention of the telegraph made it possible to distribute weather observations and forecasts, so that weather bureaus have been organized in almost every civilized country. Each of the United States Weather Bureau stations is in charge of one or more trained observers and is equipped with mercurial barometers, thermometers, wind vane, rain and snow gauge, wind velocity instruments (anemometers), sunshine recorders, barographs, thermographs, and other devices for making a continuous record of weather changes. A close study of the weather forecasts with the actual weather for the time covered shows that the forecasts are correct in about 90 of each 100 cases. How are weather observations recorded and used?

What to use. Barometer, thermometer, daily weather report from the newspaper or weather map, and large sheets of cross-section paper.

What to do. **1.** Previous to this experiment the daily weather map should have been secured from the Weather Bureau office of your forecast district. In figure 11 is given a map by means of which you may locate your own chief station, which is at the city named in your own weather-bureau district.

2. Consult the table on page 12 of the text. What should be the approximate barometer reading for the elevation of your locality? Assume that the variation of the barometer height in different types of weather will be two inches. Mark off a vertical scale on the first sheet of cross-section paper provided in connection with this problem to represent this variation on the barometer chart.

3. Keep a record of the atmospheric pressure from day to day for one month. If no barometer is available the readings can be obtained from the weather map.

4. Use the other cross-section sheet in this problem to make a record of the temperature changes. The general condition of winds, clouds, etc. should be placed at the bottom of the chart.

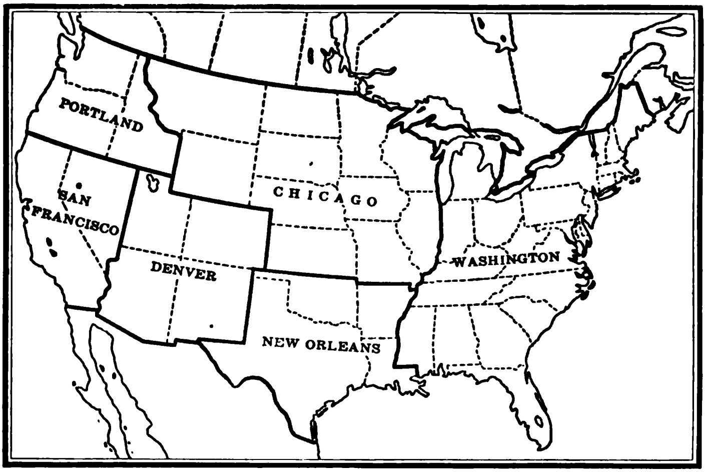


FIG. 11

5. It will be interesting to make a graph for the relative humidity of the station issuing the map. The relative humidity values can be obtained from the weather map.

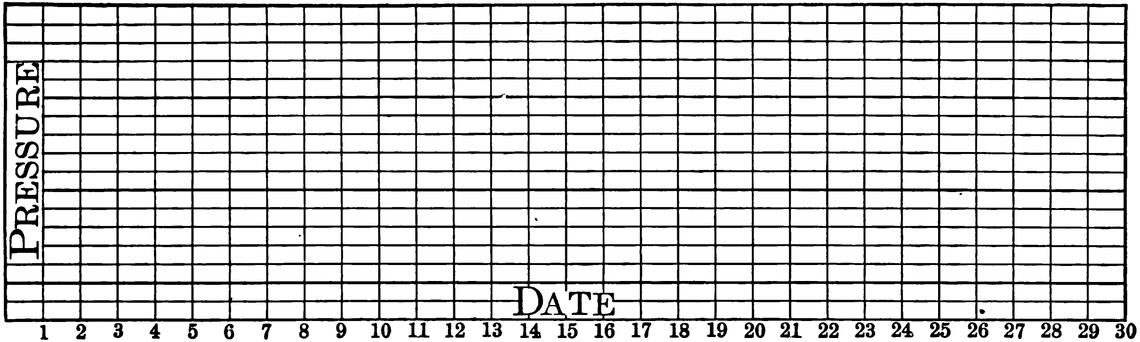
Questions. What is the average height of the barometer in your locality? the highest reading? the lowest? What relation exists between a low pressure on the one hand, and the temperature, relative humidity, clouds, and wind? What kind of weather accompanies a high pressure?

Suggestions for report. Compare your readings with those placed on a large chart (9 inches wide and 36 inches long) which has been made in your laboratory based upon the plan of the chart on page 36 of the manual. This large chart can be

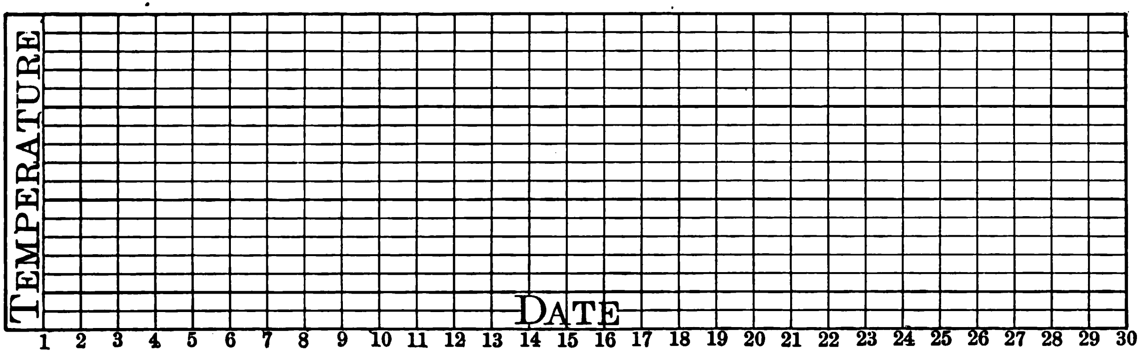
made by teacher, or teacher and pupils working together, and should be based upon daily records. It is designed to serve as a check upon the work of individual pupils.

Reference work. Read sections 38 to 43. Can you predict the weather that will accompany a low pressure? a high pressure?

Optional problems. Prepare a diagram to explain how a barograph makes a continuous record of the changing air pressure. In a similar way show how the thermograph keeps a record of the changing temperature.



Barometer and thermometer readings for month of ____________



PROBLEM 14

THE DAILY WEATHER MAP (IV-2)

The problem. The Weather Bureau is best known to the public through the daily report and weather map. The procedure is indicated in the Weather Bureau Report for 1916, which says: "Within two hours after the morning observations have been taken the forecasts are telegraphed from the forecast centers to about 1600 principal distributing points, whence they are further disseminated by telegraph, telephone, wireless telegraphy, and mail. The forecasts reach nearly 90,000 addresses daily by mail, the greater part being delivered early in the day and none later, as a rule, than 6 P.M. of the day of issue, and are available to more than 5,500,000 telephone subscribers within an hour of the time of issue." What information can be obtained from a weather map?

What to use. Supply of daily weather maps. Special bulletins entitled "Explanation of the Weather Map," and "The Weather Bureau," which may be secured from the Weather Bureau, Washington, D. C.

What to do. 1. The teacher and students should study together a daily weather map, as follows: Under "Explanatory Notes" find answers to the following questions:

a. At what time of day are the observations taken?

b. Why is the air pressure for different cities reduced to sea level?

c. What is an isobar?

d. What is the pressure on the isobar nearest your location?

e. What is an isotherm?

f. What is the temperature on the isotherm nearest your location?

g. How are the different conditions of weather indicated?

h. Describe the weather in New York, Chicago, Seattle.

i. How is rain or snow shown for large areas?

j. How many "Lows" are on the map? What is the air pressure in each?

k. How many "Highs" are on the map? What is the pressure in each?

l. Where are the local forecasts found on the map?

m. Find the pressure, temperature, wind direction, and relative humidity for your locality as given for the early morning hour.

2. What is the relation between air pressure and wind? Turn to page 39 (Fig. 24) of the text. With a compass draw a circle having a radius of one inch using the "o" of the word "Low" as a center. Count the number of arrows inside of or on the circle. Record the number in the table.

3. Place a thin sheet of paper over figure 24 of the text. Trace the outline of the circle and the word "Low." Make a dot in the circle over every arrow which points in a direction opposite that in which the hands of a clock move. Count the dots and record.

4. Repeat 3, but count only the arrows which point inward toward the "Low." Record the number.

Questions. What is the general direction of the circulation of the air about a low-pressure area? Is the general movement of air toward this area or away from it?

Suggestions for report. Record the figures in this table.

Total Number of Arrows	Arrows pointing Opposite Hands of Clock		Arrows pointing toward Low Pressure	
	Number	Per cent of total	Number	Per cent of total

Reference work. Read sections 42 to 54. What are the usual paths of low-pressure areas across the United States?

Optional problems. Try to forecast the weather every day for one week. Try the experiment suggested in figure 27 of the text.

PROBLEM 15

DANGEROUS AND BENEFICIAL MIXTURES OF GASES (V–1)

The problem. It is a familiar fact that any pronounced odor, such as that of ammonia, gasoline, benzine, or illuminating gas, is readily detected in all parts of a room soon after it is released. Usually the odor will disappear in a short time, but we seldom raise the question as to the cause of the spread of the odor or of its disappearance. Mixtures of air and gasoline or of air and illuminating gas when ignited sometimes cause explosions with fatal results. Explosions of mine gases continue to endanger the lives of miners in spite of constant efforts to obtain safety by means of special devices and precautions. In all of these cases mixtures of gases are involved. How do gases mix with one another?

What to use. Two wide-mouth bottles, one glass plate or card two inches square, matches, rubber tube two feet long, a sink or basin with water in it, and illuminating gas, or some gas-forming substance. If illuminating gas is not available ammonia gas from household ammonia water may be used.

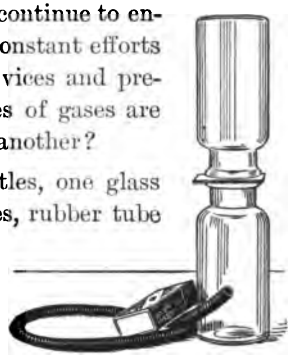


FIG. 12

What to do. 1. With pupils seated at their desks release the gas, noting the exact time of doing so. Each pupil should record the time when he first detects the gas. Open the windows to remove the gas.

2. Attach a rubber tube to a gas jet. Fill a bottle level full of water, place a glass plate or card over the top, hold it firmly, and invert it in the sink or basin of water so that all of the water remains in the bottle. The glass plate or card may now be removed. Place one end of the rubber tube under the mouth of the bottle and let the gas slowly fill the bottle. While it is under water close the mouth of the bottle with the plate or card. Bring the bottle,

mouth downward, and place it on a similar bottle filled with air (Fig. 12). Withdraw the plate and let the bottle stand fifteen minutes. Test the contents of both bottles with a burning match.

3. Repeat 2, but place the bottle containing air above the bottle containing illuminating gas.

Questions. How does the gas which was released reach all parts of the room? Is the room now "full of gas"? Why is the bottle held mouth downward? Did the heavy gas rise? Why? Did the light gas enter the lower bottle? Why? What facts are shown by the experiment?

Suggestions for report. Write a complete description of 1 or 2, telling what was done, what occurred, and why it occurred as it did.

Reference work. Read Chapter V of the text. Secure a report of a case in which illuminating gas caused fatal effects, and explain how it occurred. How should artificial respiration be used in cases of injury from harmful gases?

Optional problems. Since the gases of the air have different weights, why do they not form layers? Can you show how to pour a gas from one bottle to another? Devise an experiment to show the mixing of heavy and light liquids. Perform the experiment suggested at the bottom of page 62 of the text, using equal quantities of alcohol and water.

PROBLEM 16

RELATION OF AIR TO THE CANDLE FLAME (VI–1)

Problem. It has already been suggested that air is not composed of a single substance. We have found that water vapor is often present in a considerable amount. In the Bunsen burner, in the gas-stove burner, and in the gas lamp air is always mixed with the gas. Flames from such mixtures are very hot and have the advantage of depositing no soot. In order to obtain more information about the other gases in the air and the part they play in burning, in breathing, and in plant growth, we may begin with the simple candle flame.

What to use. Large tallow or paraffin candle, matches, Bunsen burner, glass tubing four inches long (jet tube), test-tube holder or wire, wide-mouth bottle, and lime-water solution.

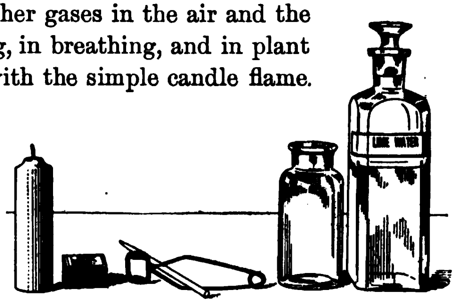


FIG. 13

What to do. 1. Light the candle (Fig. 13). Find three layers, or zones, in the flame. The inner zone is dark, the middle zone is bright, and the outer zone is a pale blue layer over the middle zone. Make a full-size drawing of the three zones and color them. Label the parts.

2. Hold a piece of white paper stretched horizontally between the hands, and quickly thrust it into the flame in such a position that the center of the paper is just above the wick. When the paper begins to char, remove it quickly. Examine for the heating effect of the different zones. Make a drawing of the charred paper.

3. Hold a match or small splinter of wood across the flame; examine as in 2.

4. Hold the jet tube (use a test-tube holder) with the large end in the center of the flame. Bring a match to the tip of the tube. Allow the tube to cool; note the inner part of the tube.

5. Hold a cool, dry, wide-mouth bottle over the candle flame so that the mouth of the bottle is about two inches from the flame. Remove and examine after about one minute.

6. Repeat 5, then add about ten cubic centimeters of limewater to the bottle, cover with the hand, and shake. (When limewater and carbon dioxide are mixed, a substance forms which clouds the water.)

Questions. Describe the appearance of the three zones of the flame. Which one is the hottest? which the coolest? What do the results with the paper and the match indicate? What do the results in 4 show? What do you observe in 5? What is the source of the substance found in the bottle in 5? Drops of water often collect on the cool kettle when a gas stove is lighted. Explain. What results do you get in 6? Explain.

Suggestions for report. After class discussion write correct answers for the questions given above and use this statement and the drawings as a report of the experiment.

Reference work. Read sections 65 to 75.

Optional problems. Perform this experiment with the Bunsen flame. Note carefully the results and compare with the results of the experiment with the candle flame. Explore the Bunsen flame with a match head to see if the match may be held in the flame without burning it. Expose a wide dish of limewater to air for twenty-four hours. Note and explain the results. Study the gas stove and compare it with the Bunsen burner.

PROBLEM 17

NATURE OF THE WATER PRODUCED IN THE CANDLE FLAME (VI–2)

Problem. The results of previous experiments indicate that water is one product of the candle flame and the gas flame. What is the source of this water and what is the process by means of which it is produced? In 1781 water was shown to be a compound of two gases. It is possible to obtain interesting information by decomposing water. This can be done by sending an electric current through water (properly treated) and collecting the products.

What to use. Ring stand, one ring, milk bottle (see appendix, p. 181, for method of removing the bottom), rubber stopper to fit, two carbon rods, connecting wires, three or four dry cells, switch, concentrated sulfuric acid, two eight-inch test tubes, and matches. The apparatus illustrated on page 67 of the text can be used.

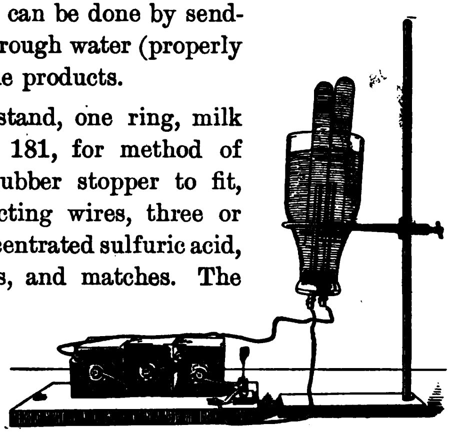


FIG. 14

What to do. 1. Assemble the apparatus as shown in figure 14. Partially fill the bottle with water and measure it. Then pour into the bottle of water, slowly and with constant stirring, one part of concentrated sulfuric acid for each twenty parts of water. **Caution!** Do not pour water into the acid.

2. Fill two test tubes with the water and invert them, as shown in the figure.

3. Let the current flow through the solution until one tube is half full of gas. Note the quantity that is in the other tube. For exact quantities use apparatus shown on page 67 of the text.

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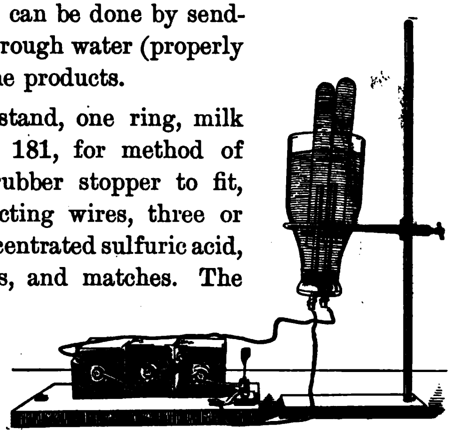

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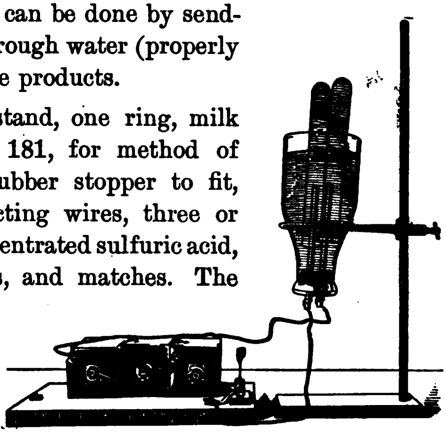

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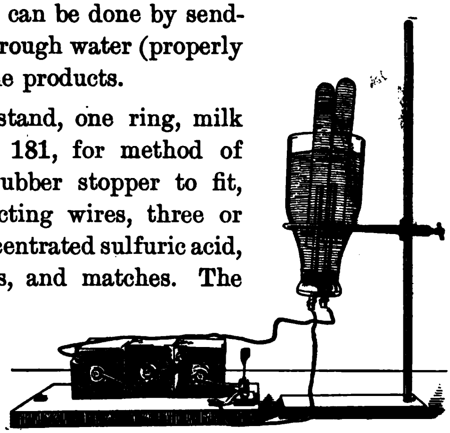


FIG. 14

What to do. 1. Assemble the apparatus as shown in figure 14. Partially fill the bottle with water and measure it. Then pour into the bottle of water, slowly and with constant stirring, one part of concentrated sulfuric acid for each twenty parts of water. **Caution!** Do not pour water into the acid.

2. Fill two test tubes with the water and invert them, as shown in the figure.

3. Let the current flow through the solution until one tube is half full of gas. Note the quantity that is in the other tube. For exact quantities use apparatus shown on page 67 of the text.

4. Test each gas with a burning match; with a glowing splint. Repeat until you are sure what to expect in each case.

5. Determine whether the carbon or the zinc of the battery is connected with the tube in which the larger amount of gas is formed.

Questions. Which gas burns? What product is formed? How can you recognize the other gas? Which terminal gives the larger volume of gas? How are the gases alike? how different? Trace the path of the electric current from the switch through the circuit. What are the important facts shown by the experiment? What is a compound? an element?

Suggestions for report. Make a diagram of the apparatus; name all the parts; show the direction of the current; and name each gas in the tubes.

Reference work. Read sections 68 to 72. Make a list of all of the elements that you use in one day. Arrange these in order of their importance.

Optional problems. Fill a dry test tube with hydrogen. Bring a flame to the tube and watch for a new product. Explain. Find out from a chemistry text how hydrogen and oxygen are prepared in commercial quantities.

PROBLEM 18

NATURE OF CARBON DIOXIDE AND ITS RELATION TO RESPIRATION (VI-3)

Problem. Carbon dioxide is constantly being added to the air by the burning of all fuels, by the process of respiration, and by the decay of animal and plant substances. On the other hand, growing plants use great quantities of carbon dioxide from the air and return some oxygen. In order to find out more about carbon dioxide it is best to obtain it in quantity from an experiment other than that of the burning process. How can this be done?

FIG. 15

What to use. Ring stand, burette clamp, marble, hydrochloric acid, special test tube with side neck and one-hole rubber stopper to fit, glass plug, glass jar or sink, three ordinary test tubes or wide-mouth bottles, small candle, wire, charcoal, wood splints, forceps, filter paper or glass plates, test-tube stand, Bunsen burner, and limewater.

What to do. 1. Assemble the apparatus as shown in figure 15. Put some pieces of marble in the test tube and cover them with

water. Fill another test tube or a wide-mouth bottle with water and invert it as shown in the figure. Put the end of the rubber tube in this test tube or bottle.

2. Directions for handling such chemicals as hydrochloric acid etc. will be found in the appendix, p. 181. Add some hydrochloric acid to the marble and insert the rubber stopper in the test tube. Fill three test tubes or bottles with carbon dioxide gas; cover them with wet filter paper or glass plates and set them right side up.

3. Study the nature of the carbon dioxide according to the table given in suggestions for report.

4. Pour off some of the liquid above the marble, put it into a test tube, and evaporate almost to dryness. Set the tube aside to cool.

Questions. How do you recognize marble? hydrochloric acid? What occurs as the acid is added to the marble? Is the marble destroyed? How can you tell when the vessel is filled with carbon dioxide? How does carbon dioxide behave toward a burning splint? a burning candle? a glowing charcoal?

Suggestions for report. Record the facts in the table below:

Substance	Color	Odor	Taste	Weight compared to air	Action on burning splint	Action on glowing charcoal	Action on candle	Action on lime-water

Reference work. Read sections 73 to 76.

Optional problems. Weigh a large beaker of air. Fill the beaker with carbon dioxide and weigh it again. Explain. Devise a method for detecting carbon dioxide in a well. How can the carbon dioxide be removed? Study a fire extinguisher and give an explanation of its action. How is carbon dioxide used in connection with the soda fountain?

PROBLEM 19

COMPARATIVE STUDY OF THE ELEMENTS OXYGEN AND HYDROGEN (VI–4)

The problem. Having made a study of the two compounds, water and carbon dioxide, as given off by the candle, it will be interesting to study the elements, oxygen and hydrogen, and to compare them with carbon dioxide. Oxygen was discovered in 1774. It forms eight ninths of water by weight and about 65 per cent of

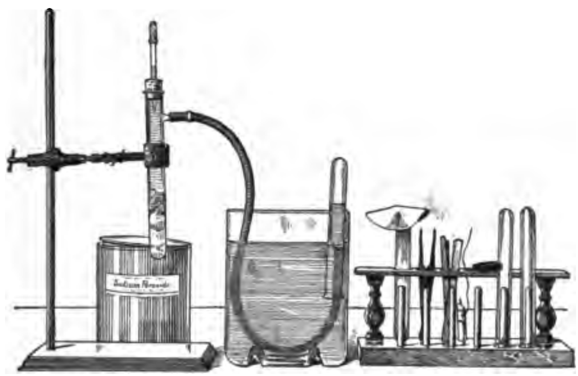


FIG. 16

the human body. It is required for the life processes of all living things. Hydrogen is the lightest element known and was discovered about 1766. About 10 per cent of the human body is hydrogen. Combined with carbon it is found in petroleum and natural gas.

What to use. Ring stand, burette clamp, sodium peroxide, medicine dropper, zinc, hydrochloric acid, test tube with side neck, and one-hole rubber stopper to fit, glass plug, rubber tube, glass jar or sink, three test tubes or wide-mouth bottles, small candle, wire, charcoal, wood splints, forceps, filter paper or glass plates, test-tube stand, Bunsen burner, and limewater.

What to do. 1. Arrange the apparatus as shown in Fig. 16. Fill a vessel with water and invert it in the jar or sink. Insert the rubber tube in the vessel. Put about a tablespoonful of sodium peroxide powder on a dry sheet of paper, then let the powder slide into the side-neck test tube. Fill the medicine dropper with water and insert it in the stopper. Drop some water on the sodium peroxide and collect the oxygen which is evolved. (A chemical change between the water and sodium peroxide produces oxygen and caustic soda, or sodium hydroxide. The gas escapes and the caustic soda remains in solution.)

2. Collect samples of oxygen until you have made all of the observations suggested on page 50.

3. Pour the solution from the test tube into a large bottle, which should be stoppered with a rubber stopper and kept for future use. Wash the test tube.

4. Put some zinc into the test tube and cover the zinc with water. Substitute a glass plug for the medicine dropper. Pour some hydrochloric acid into the tube and collect the hydrogen gas. (The chemical change produces free hydrogen, also zinc chloride which remains in solution. This solution should be saved.)

5. Collect samples of hydrogen until you have made all of the observations suggested on page 50.

Questions. Does the test-tube generator get warm? Why? How do you recognize the sodium hydroxide solution?

Suggestions for report. Record the observations in the form given on page 50.

Reference work. Read sections 69 to 72 and 74. Write out a definition for an element, a mixture, a compound, an atom, and a molecule.

Optional problems. Plunge a white-hot piece of picture wire into a bottle of oxygen. It is best to have some water in the bottle. Pass hydrogen bubbles through a solution of sodium hydroxide, then into a good soap-bubble solution.

PROBLEM 20

IS STARCH PRESENT IN PLANT TISSUES? (VII–1)

The problem. A very common food substance in plants is starch. It is probably known to most of us that there is no source of starch from which most plants can secure it. It would seem probable, therefore, that the plant must make it from such raw materials as it is able to secure. As a first step in investigating the origin of starch and other food materials in plants we need to know of what these foods are composed and whether they are simple substances or compounds.

What to use. Some commercial starch, a piece of fresh white potato, a white-spotted or partially green leaf (as some kinds of geraniums), a dilute solution of iodine (tincture of iodine), and glass plates.

What to do. 1. Place some commercial starch upon a glass plate. Put a drop of the iodine upon the starch and observe the color changes of the starch.

2. Do the same with a thin slice of potato.

3. Place several drops of iodine upon one of the light spots of a leaf and after five or ten minutes remove the iodine and see if the color indicates that there is starch in the leaf.

Questions. What is the color of pure starch when treated with the iodine solution? Do the fresh potato and commercial starch show the same color when so treated? Does the leaf? Do you note any color changes in the green part of the leaf? What inferences do you make, and why?

Suggestions for report. Describe the effects of the iodine solution upon starch, and the use of this as a means of finding whether starch is present in plant tissues and in food materials.

Reference work. Read sections 80 to 85.

Optional problems. Apply the above test to other foods. What plants furnish most of the world's supply of starch?

PROBLEM 21

RELATION OF WATER AND CARBON DIOXIDE TO COMPOSITION OF STARCH (VII–2)

The problem. Since starch is one of the most important foods for men and animals it is worth while to learn something about its composition. In order to approach this problem we need first to be able to answer the questions: Is starch a simple substance or a compound substance? If it is a compound, of what is it composed?

What to use. A dry test tube, a small amount of dry starch, and a flame from gas or alcohol.

What to do. 1. Heat the test tube to make sure that it is quite dry. Pour into it enough starch to cover the bottom of the tube. Then, while carefully observing what occurs, heat the tube and starch slowly until the starch is changed so that none of it has the white color which it had when the experiment began.

Questions. What are the drops which appear upon the inner walls of the test tube? Where do they come from? Remove some of the black material from the bottom of the test tube and try to determine what it is. In what way does it differ from starch?

Suggestions for report. Describe what occurs when starch is heated in a dry test tube.

Reference work. Read sections 85 to 90. Make a list of the uses to which starch is put in your home and community. See if you can find printed articles which describe the commercial preparation of starch.

Optional problems. Pulverize and dry some starch from a white potato and repeat this experiment with this starch. Are the results like those previously observed? When the potato is pulverized does the result include anything besides starch? Can you determine whether the heated starch gives off carbon dioxide?

PROBLEM 22

RELATION OF CHLOROPHYLL TO THE REST OF THE LEAF (VII-3)

The problem. Some leaves are white-spotted, some clear green, some brown, or of other colors. In the starch tests no very satisfactory results could be seen on the parts of the leaf which were green. Can this green material known as "chlorophyll" be removed from the leaf?

What to use. Some fresh green leaves (such as those of nasturtium or geranium), two wide-mouth bottles and stoppers to fit, alcohol, boiling water, and iodine solution.

What to do. 1. Dip a few leaves in boiling water, then place them in a bottle of alcohol. Insert the stopper in the bottle.

2. Place others in another bottle of alcohol without having dipped them in boiling water. Insert the stopper. Allow both bottles to stand for two or three hours to see whether the chlorophyll behaves in the same way in both.

3. After twenty minutes remove one of the leaves which was dipped in boiling water and, after rinsing in cold water, note its color. Treat it with iodine to see if it contains starch.

Questions. What happened to the chlorophyll in both sets of leaves? What differences were there between the two cases? Is the chlorophyll always a part of the leaf? Does absence of chlorophyll make it possible to determine presence of starch by use of the iodine test?

Suggestions for report. Describe how to remove chlorophyll from a leaf. Tell what chlorophyll is, and how dipping a leaf in hot water affects the removal of chlorophyll by alcohol.

Reference work. Read sections 87, 92, 93, and 94.

Optional problems. Try the tests given above on leaves which have been in darkness for at least ten hours.

PROBLEM 23

HOW GASES PASS INTO AND OUT OF A LEAF (VII-4)

The problem. Within green leaves and other green parts of plants carbon dioxide and water are made into foods. The water comes up through the plant from the roots. Carbon dioxide and other gases enter and leave the leaf. What is the structure of the leaf which permits the passage of gases?

What to use. Some rather thick leaves (those of the life plant (*Bryophyllum*) and live-forever are good, as are most kinds of lily, iris, and amaryllis), hand lens, compound microscope, sharp knife or razor, glass slides, and cover glasses.

What to do. 1. Peel off a small piece of the "skin" (epidermis) from each surface of the leaf, noting especially its thinness and transparency. Place these thin pieces in a drop of water on a microscope slide, under a cover glass, and examine with a hand lens and with the microscope. (See appendix, p. 182, for suggestions on the use of the microscope.) Find how the different cells of the epidermis are arranged, especially the cells and openings of the "breathing pores," or stomata.

2. Examine a cross section of a leaf with the microscope.

Questions. Why are stomata often called "breathing pores"? Is the stomatal opening of the same size in all stomata? Do you think one of the openings changes in size at different times? Does the opening connect with air spaces within the leaf? Do these openings provide ready passageways for gases to and from the outside air?

Suggestions for report. Make a diagram of a surface view of leaf epidermis and label the parts. Prepare a diagram of a cross section of the leaf and name the parts.

Reference work. Read sections 86 to 90, and the discussions of leaf structure in elementary texts on botany.

Optional problems. Allow a piece of a leaf with the epidermis removed to lie upon the table for a while and note and explain the effects upon the interior leaf tissues. Make a clay model illustrating the appearance of a leaf in cross section.

PROBLEM 24

OXYGEN PRODUCTION DURING FOOD MANUFACTURE (VII-5)

The problem. Plants not only absorb carbon dioxide gas but give off a gas when they are manufacturing food. This is often noted when gas bubbles are forming about water plants in the sunlight. Can this gas be collected and examined? If various agencies are constantly using oxygen from the air and adding carbon dioxide to it, why does the oxygen not disappear?

What to use. An aquarium containing submerged and thrifty water plants (water weed, the pondweeds, water milfoil, and hornwort are common water plants in most parts of the country), test tube, and funnel.

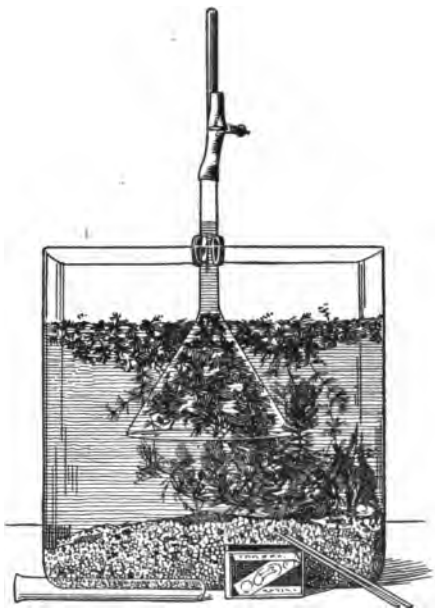


FIG. 17

What to do. 1. After the aquarium containing a good supply of water plants has stood in the sunlight for fifteen or twenty minutes, gas bubbles may usually be seen to rise from the plants. Collect some of this gas in an inverted test tube (Fig. 17). Test the gas (p. 50) to determine what it is.

2. Place the aquarium in a dark room for a half hour and see if bubbles of this gas are still present.

Questions. In what sense is it true that a green plant is an oxygen-producing machine? Why does oxygen appear only after a period of exposure of the plants to sunlight? At what rate is the gas produced? How does the plant get its carbon dioxide? Is there oxygen in the water?

Suggestions for report. State how oxygen is released by green plants when they are under the direct rays of sunlight.

Reference work. Read sections 90 to 98.

Optional problems. In drinking troughs for domestic animals where water stands for a long time, small threadlike green plants (pond scums) often are found growing. See if you can find any oxygen bubbles in such places. Do land plants produce oxygen as water plants do? Of what significance is it to other living things to have green plants use carbon dioxide and release oxygen? Do green plants ever use oxygen and release carbon dioxide?

PROBLEM 25

HOW DO MOLDS LIVE AND GROW? (VIII-1)

The problem. Since green plants can manufacture foods from carbon dioxide and water they are more nearly independent than are plants which do not have chlorophyll. How do the non-green plants get their food?

What to use. A piece of bread or stale banana, a glass plate or dish with a cover (Fig. 18), and a magnifying glass.

FIG. 18

What to do. 1. Moisten a piece of bread slightly and expose it to the dust of the room for about an hour, then cover it to prevent drying and put it in a dark, warm place. If the banana is used treat it similarly, except it is not necessary to moisten it. Observe daily. One or more varieties of mold are likely to appear within four or five days. Examine carefully under the magnifying glass.

Questions. What was the appearance of the mold when first you could detect it? What changes in appearance occurred in the following days? Is there any evidence that the mold consumes part of the bread or banana? The black masses produced consist of reproductive spores. How are these spores distributed to new growing places?

Suggestions for report. Describe what was done and what occurred. State how mold plants reach new growing places.

Reference work. Read sections 92, 102, and 103. Read a description of a parasitic plant in a textbook of botany or a government bulletin; also a description of the damage done to crops by dependent plants.

Optional problems. Do mushrooms and molds contribute to the oxygen supply of the atmosphere? Do animals? If bread or fruit which is entirely mold free is kept closed within a mold-free dish will molds develop on this bread or fruit? How can a bread box be cared for so as to prevent the growth of molds? In what ways is the life of rusts and smuts like that of the molds? What other plants do you know which live without the direct use of chlorophyll?

PROBLEM 26

HOW DO YEAST PLANTS LIVE AND GROW? (VIII-2)

The problem. Yeasts are dependent plants, each one of which is so small that when separate it can be seen only by use of a microscope. Notwithstanding their smallness, the way in which yeasts grow has caused these plants to become of very great domestic and commercial importance. How do yeasts grow?

What to use. Cake of yeast, a sugar or molasses solution (this solution should not be stronger than 10 per cent, and a satisfactory solution can be made of corn sirup), large bottle, one-hole rubber stopper to fit, glass tubing or rubber tubing, graduate, test tube, and limewater.

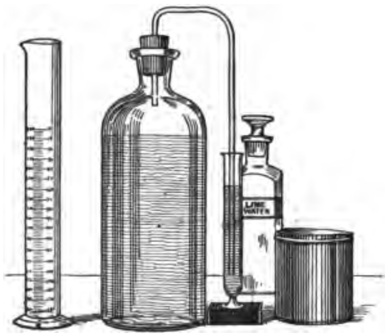


FIG. 19

What to do. 1. Arrange the apparatus as shown in figure 19. The test tube should contain limewater. Mix the yeast with a few cubic centimeters of water before adding it to the sugar solution. Observe the apparatus every two or three hours.

Questions. Does a sediment or scum form in the water? Is there any gas formed? Is the limewater changed? What does this show? Has the solution an odor? What is its source?

Suggestions for report. Draw a sectional diagram of the apparatus used, name the parts, and mention at least three products that are formed.

Reference work. Read sections 99 to 103.

Optional problems. Pour some of the fermenting yeast solution into a flask, heat to boiling for a few minutes, then close the

flask with cotton and observe from day to day. Study a drop of the yeast solution with a compound microscope. Will a 5 per cent sugar solution ferment if exposed to the air? How do yeasts cause bread to rise? What conditions are needed for the best work of yeast plants in bread making? What results will follow if bread rises too long?

PROBLEM 27

BACTERIA IN THE AIR (IX-1)

The problem. Bacteria are extremely small plants. Most of them are much smaller than yeast plants, and it is difficult to study one or a few of them, even when the most powerful microscope is used. Yet, though the organisms themselves cannot ordinarily be seen, it is not hard to study them by observing their effects.

What to use. Some fruit juices or gelatin plates (which can usually be secured from the local public-health officer) and glass dishes with overlapping glass covers.

What to do. 1. Heat the fruit juice or the gelatin plates and the clean glass dishes to about a boiling temperature on three successive days to make certain that no living organisms remain.

2. Then expose different dishes of juice or gelatin in different ways: for example, place one in the school hallway for ten minutes; insert a pencil point into another for one-half minute; etc. Keep one or two dishes unexposed as tests of the purity of the material used. Keep all closed dishes under the same conditions and observe from day to day. See if the liquid becomes cloudy or if colonies of bacteria develop in the gelatin. If colonies develop count them and note any differences in form, color, or effects upon the gelatin.

Questions. Do these colonies cause the decay of the fruit juice or gelatin? Are bacteria small enough to be carried by the air? Does most air contain bacteria? Can materials be sterilized and kept so that no bacteria will grow in them?

Suggestions for report. State what was done in the above experiments and describe any results secured from the different exposures of the nutrient materials used.

Reference work. Read sections 112 to 116.

Optional problems. Can you devise an experiment to show whether the practice of some pupils of putting pencils in their mouths is wise? Why is the air one of the leading means of distribution of bacteria? What are some of the leading methods used in sterilizing fruit for canning and for preventing growth of bacteria in the canned fruit?

PROBLEM 28

CHANGES IN VOLUME WHEN WATER FREEZES (X–1)

The problem. We have seen that air, water, and mercury expand when heated and contract when cooled. This is true of most substances. Thus, if melted lard, tallow, wax, or paraffin is poured into a vessel and allowed to cool, it will be found that when it has solidified there is a depression of the surface and possibly there are cracks in the center, indicating that the material has contracted noticeably even after it began to harden. On the other hand, it is commonly noted that water when freezing may break the containing vessel, or the surface of the mass of ice may be bulged up, thus apparently showing expansion. What are the facts regarding the behavior of water when it freezes?

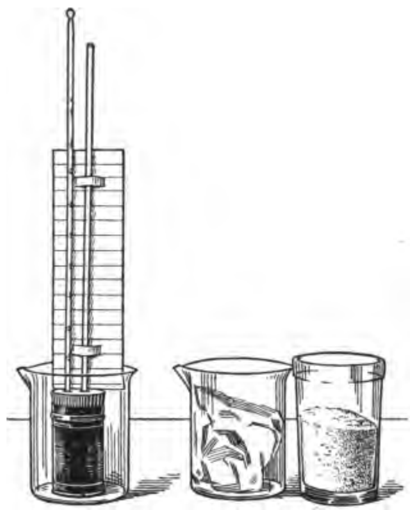


FIG. 20

What to use. Thermometer, glass tube, two-hole rubber stopper, beaker or drinking glass, ice, salt, sheet of centimeter cross-section paper, and a small metal can, glass vial, or test tube. A small baking-powder or paprika can is satisfactory.

What to do. 1. Assemble the apparatus as shown in figure 20. Fill the metal or glass vessel with water which has a temperature of about 40° C., and close it with a two-hole rubber stopper containing a thermometer and a glass tube. In handling

thermometers in stoppers care is needed to avoid breaking the thermometer. Thermometers and glass tubes should be grasped near the stopper, turned slightly, and thrust into the stopper. Push the stopper into the can or vial until the glass tube is about one fourth full of water. Fasten a paper centimeter scale back of the tube.

2. Set the metal vessel in a beaker or cup and surround it with a freezing mixture made by adding ice or snow to a strong salt solution.

3. Mark the water level on the scale. Call all readings below this minus (−) and all above it plus (+). Record the readings every minute for from thirty to sixty minutes as follows:

TIME	TEMPERATURE	CHANGE IN VOLUME

Questions. Will the experiment be a fair test if there is air between the stopper and water level? What temperature is produced by the freezing mixture? Describe the changes in volume. At what temperature does the water have the least volume? greatest volume? At what temperature is a cubic inch of water the heaviest? Why is the freezing temperature of water used in making thermometer scales?

Suggestions for report. Make a graph showing the change in volume with the change in time. On the same page show the change in temperature with the change in time. On the blank portion of the cross-section paper draw a cross-section diagram of the apparatus used.

Reference work. Read sections 131, 134, 144, and 145. Explain the following: Why does ice float? Why do lakes and ponds not freeze solid? Why do water pipes burst in cold weather?

Optional problems. Try the above experiment with other liquids.

PROBLEM 29

WHAT HAPPENS WHEN WATER BOILS? (X-2)

The problem. The use of boiling water and steam in the affairs of everyday life is so extensive that we seldom raise questions about the process of boiling. Does water always boil at the same temperature? Does the air pressure influence the process? Why is the double boiler used in cooking? Does water boil at ordinary temperatures at sea level and on a mountain? Does the presence of salt or sugar in the water affect the process? These questions and others are best answered by a careful study of the process of boiling.

What to use. Ring stand, two rings, wire gauze, flask (500 cc.), thermometer, glass tubing, two-hole rubber stopper, Bunsen burner, matches, test tube, beaker, wide-mouth bottle, salt, ink, sawdust, and rubber tubing.

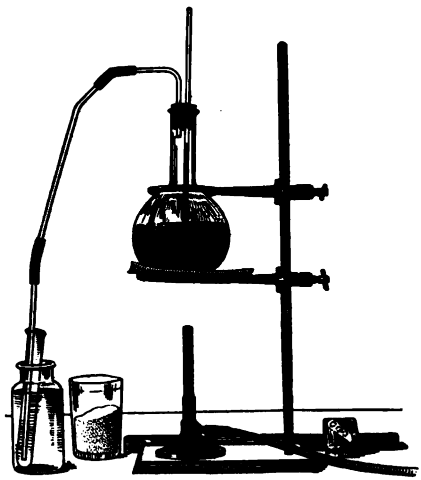


FIG. 21

What to do. **1.** Assemble the apparatus as shown in figure 21. Add a small amount of sawdust to the clear water. Note the temperature of the water, then heat it slowly. Note the movement of the sawdust. When the water is boiling vigorously note the temperature. When boiling has begun does the temperature rise if more heat is applied? Remove the Bunsen burner.

2. Slide the thermometer up out of the water, then boil the water and note the temperature of the steam.

3. Add some salt or sugar; note the temperature of the boiling water and of the steam.

4. Add some ink to the water, connect the long tubes shown in figure 21, and let the steam pass into the cold test tube.

Questions. Why is a wire gauze used under the flask? Does a film appear on the flask? Why? At what temperature do small bubbles appear? Explain the behavior of the sawdust. Is there a difference between the temperature of boiling water and that of steam? between that of salt water and that of steam? Do the salt and ink pass over with the steam? Why?

Suggestions for report. Write a summary of this experiment, giving a complete statement for each important fact.

Reference work. Read sections 132 to 137.

Optional problems. If a strong round-bottom flask is available, the following experiment may safely be performed with interest: Boil the water several minutes, then remove the flame and close at once with a rubber stopper. Invert the flask on a ring stand. Wet a towel with cold water and put it on the flask. Explain. By use of a thermometer determine the temperature at which cooking food simmers.

PROBLEM 30

EFFECT OF EVAPORATION UPON TEMPERATURE (X–3)

The problem. If one stands on the beach after bathing he soon becomes chilled, even though it is a warm day. If the wind is blowing the cooling effect is greater. Alcohol, gasoline, and ether produce a sensation of coldness as they evaporate from the hand. Artificial ice is manufactured by the cooling effect of liquid ammonia which is evaporating rapidly. To what extent does the rapid evaporation of different liquids affect the temperature?

What to use. Ring stand, thermometer, burette clamp, rubber stopper, some clean cotton, rubber band, water, alcohol, and fan.

What to do. 1. Arrange the apparatus as shown in figure 22. Record the temperature of the room. Twist a small piece of cotton around the bulb. Fasten this with a rubber band. Wet the bulb with water at room temperature. Fan the thermometer until no further change is produced. Record the temperature.

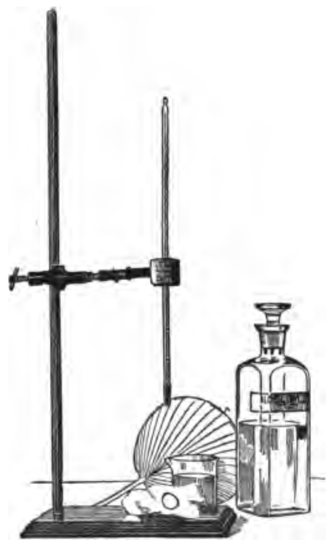


FIG. 22

2. Repeat the experiment, using alcohol.

3. The relative humidity of the room can be obtained from the results in 1. The change in temperature on the wet-bulb thermometer depends upon the moisture present in the air. Tables have been devised which will give the relative humidity direct, with no calculation. Find the value for your readings from the graph in figure 23.

Questions. What happens as the water evaporates from the cotton? How does the movement of air affect the temperature? What results are obtained with alcohol? What is the relative humidity of the room? Account for the temperature changes.

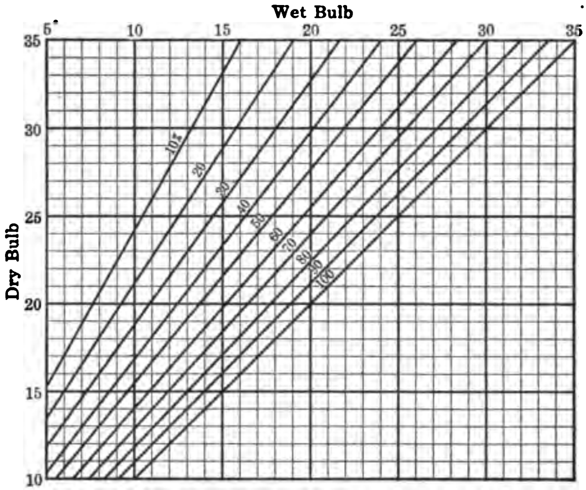


FIG. 23

Suggestions for report. Record the observations as follows:

Room temperature (dry bulb) . . . .
Room temperature (wet bulb) . . . .
Lowest temperature obtained with alcohol . . . . . .
Relative humidity of room . . . .

Reference work. Read sections 138 to 144.

Optional problems. Weigh a beaker, add 200 grams of water, and set it aside in a quiet place in the room. Weigh the beaker each day to determine the rate of evaporation. By means of the apparatus shown in figure 61 of the text and the graph used in this experiment find the relative humidity of several rooms. Write to the New York State College of Agriculture for directions for constructing an iceless refrigerator, and determine the principles and processes involved in this device.

PROBLEM 31

EVAPORATION OF WATER FROM A PLANT (X-4)

The problem. The weight of water evaporated into the air from a large tree in one sunshiny and warm day may be as great as the weight of ten general-science students of average size. Is it possible to demonstrate that plant leaves transpire (that is, lose water to the air) and also to measure the exact amount transpired from some of the smaller plants?

What to use. Dry bottle with a split cork stopper, three potted plants, sheet of thin rubber (dentist's rubber) large enough to inclose the pot in which one of the plants grows, pair of balances or any accurate scales, string, ring stand, and burette clamp.

FIG. 24

What to do. **1.** Insert a few leaves from one of the plants into the bottle and fit the split cork into the bottle about the stem so that the bottle is closed about some of the leaves (see Fig. 64 of the text). Support the bottle so that its weight will not rest upon the plant. Observe from hour to hour to see if drops of water appear in the bottle.

2. Wrap the pot of another plant (Fig. 24) with the sheet rubber and tie it so as to hold the rubber tightly about the stem, making sure not to injure the stem.

3. Weigh the third pot and plant, also the wrapped pot and plant, set in a light place, and weigh regularly. Record the weights.

Questions. What does loss of weight of the wrapped pot indicate? Is rate of loss the same at all periods? Account for any differences. What are the reasons for wrapping the pot with rubber?

Suggestions for report.

DATE	TIME	WEIGHT	LOSS PER HOUR

Reference work. Read sections 142 and 143. Consult texts in botany or agriculture giving amounts of water given off by fields of crop plants.

Optional problems. What is the source of the water constantly being transpired by growing plants? What becomes of this water?

PROBLEM 32

HOW LIQUIDS ARE TRANSFERRED BY THE SIPHON AND LIFT PUMP (XI-1)

The problem. In the early days a single spring of water was often sufficient to furnish the required supply. Modern life has increased the demand for water from a few gallons per day to an average of more than 30 gallons per day per person for the medium-sized town. The average daily consumption per individual in New York is about 100 gallons. It is more than 200 gallons per day in Chicago. These demands make special devices necessary for transferring water. The Los Angeles water-supply system makes use of a great steel siphon. In some systems water flows by the force of gravity to its destination, while in others pumps must be used.

FIG. 25

What to use. Two wide-mouth bottles, glass U-tube, water, six-inch calcium chloride tube, copper wire, cork, rubber sheet, rubber tubing, glass tube one foot long, ring stand, and burette clamp.

What to do. 1. Set up the siphon as shown in figure 25. Start the siphon by filling the tube with water, placing the finger over one end and inverting the other end in the bottle of water. Place the bottles on the table and compare the water levels when the water ceases to flow. Raise one bottle, then the other.

2. Assemble the model lift pump as shown in figure 26. See that the piston of sheet rubber fits the tube closely. Try to raise water from the bottle by moving the dry piston up and down. Pour some water on top of the piston and try to operate the pump. Improve the pump action until water flows from the spout at each upward stroke.

3. Note the three stages of operation as follows: (1) action on downstroke; (2) upstroke; (3) action of valves in (1) and (2).

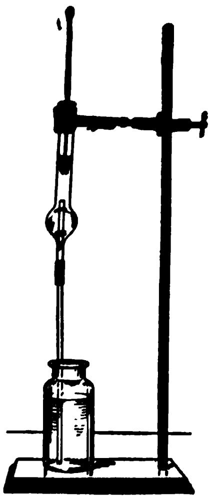


FIG. 26

Questions. Why must the siphon be filled with water? Why does the water remain in the tube when one end is closed? When does the siphon cease to operate? Why? What are the essential parts of a lift pump? Why does the pump lift the water? Explain 3.

Suggestions for report. Make a cross-section drawing of the siphon and explain how it operates (see page 129 of the text). Make drawings to show the action of the valves in 3.

Reference work. Read sections 147 to 149.

Optional problems. Can you construct a force pump? Can you make a self-starting siphon? Examine an ordinary lift pump and make a diagram to explain its action.

PROBLEM 33

WHAT DETERMINES WHETHER OBJECTS FLOAT OR SINK? (XI–2)

The problem. A submarine boat may float, travel under water at a given depth, or sink, depending upon the will of the crew and the perfection of the machinery. In a similar manner a balloon may rise in the air, travel at a given elevation, or descend to the earth. What is it that determines whether an object will float or sink in a fluid?

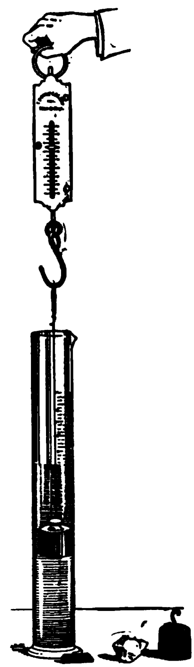


FIG. 27

What to use. Spring balance (250 grams); iron or carbon rod; piece of stone, coal, lead, brass, aluminum, tin, or other solid; string; water; and graduated cylinder (metric).

What to do. 1. Use the apparatus shown in figure 27. Note whether the pointer of the balance is at zero. What is the value of the smallest division on the balance? Estimate the fractions of divisions if necessary. Weigh the object in the air.

2. Next weigh the object in water.

3. Fill a graduated cylinder about half full of water. Read accurately the volume of water. By means of a string lower the object into the water and read the volume again. Record the readings.

Questions. What mistakes are easily made in using a balance? What is the least weight that the balance will register? Explain why there is a difference between the weight of the object in air and its weight in water. What is the proper method for reading the water level in the cylinder? Why does lowering the object into the water change the level?

Suggestions for report. Write complete answers to the questions given above. Corrected records of the experiment should be recorded in the table.

Weight in air	. . . .
Weight in water	. . . .
Loss of weight	. . . .
Volume of water displaced	. . . .
Weight of water displaced	. . . .
Volume of object	. . . .
Weight of one cc. of object	. . . .

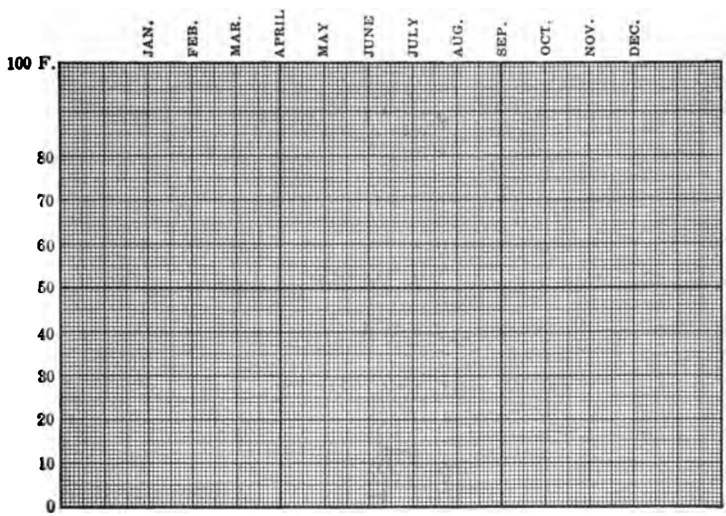
Reference work. Read sections 153 to 157. What is meant by density? A boy can lift a large stone to the surface of the water but not above the water. Why?

Optional problems. What weight will the object weighed above lose in gasoline, kerosene, or milk? How can you find the density of a liquid? Does the density of a sugar solution change during boiling? Why?

PROBLEM 34

EFFECT OF A LARGE BODY OF WATER UPON THE TEMPERATURE OF THE REGION NEAR IT (XII-1)

The problem. Certain cities frequently are advertised as desirable summer resorts when much is made of the nearness to lakes or oceans. What is the real or supposed influence which these bodies of water exert on the temperature?



What to use. Cross-section paper and the data given on page 143 and in figure 76 of the text.

What to do. 1. Note the relative locations of the three cities as shown on the map on page 147. By use of the mean monthly temperature data (p. 143) and the cross-section paper above, prepare a curve showing the temperature variation for each city for the full year. Each line should be labeled. Use different colors if possible.

Questions. Which of the three cities referred to has the lowest average and which the highest average temperature? How are the summer temperatures of the three places related? the winter temperatures? Which place has the greatest annual variations in temperature? Could the lake be responsible for the differences in temperature of the three places? How?

Suggestions for report. Write a brief statement showing how lake or ocean cities differ in temperature from inland cities.

Reference work. Read sections 158 to 166.

Optional problems. Compare temperatures at a given point in California and at points in approximately the same latitude in the Rocky Mountains, Central States, and along the Atlantic coast. Study the temperature curves on pages 142 and 149 and see whether temperature in both cold and hot waves seems to be influenced by lakes. Why are there many productive peach orchards on the east shore of Lake Michigan and few or none on the west shore?

PROBLEM 35

WATERWAYS AND HARBORS (XIII-1)

The problem. Most young persons will be surprised when they look at the map on page 153 of the text to see the number and extent of navigable rivers in the United States. The harbors, which cannot be well shown on such a map, are equally numerous and equally important. A study of some one waterway system should prove of interest.

What to use. The map on page 153 of the text and maps or charts of the nearest waterways or ports. These may be had at small cost, or free, from the proper government authorities, as follows: Coasts of the United States, U. S. Coast and Geodetic Survey, Washington, D. C.; Great Lakes, U. S. Lake Survey Office, Detroit, Mich.; Mississippi River, Mississippi River Commission, St. Louis, Mo.; Prevention of River Floods, Ohio River Valley Flood Commission, Dayton, Ohio.

What to do. 1. The conditions and facts of different waterways vary so largely that the work to be done cannot be outlined specifically. The work should include a study of the extent and use of the watercourse, the channels, depths, obstructions, lighthouses, buoys, fog signals, and wharves and other facilities for loading and unloading.

Questions. Is water transportation of much importance in the United States? What are the features most desirable in a river for use as a means of transportation? What are the requirements of a good harbor? What are "Eads jetties," and how and why were they constructed? What were the causes of the Ohio River Valley flood of 1913, and what means are being used to guard against a repetition of such floods?

Suggestions for report. Write a brief statement of the nature, extent, and use of any particular waterway you have studied.

Reference work. Read sections 167 and 168 and any printed descriptions of the waterways of your part of the country.

Optional problems. With a leading product as a basis for discussion,—as cotton, wheat, coal, iron, or lumber,—indicate the points to which the major part of the output is shipped and the chief routes of shipment, and thus show the extent to which water enters into the transportation of this product.

PROBLEM 36

LOCAL IMPORTANCE OF WATER TRANSPORTATION (XIII-2)

The problem. It is likely that every community in the United States uses some articles which have been carried in part by water transportation. Thus, to an extent, every community is partly dependent upon water transportation.

What to use. Maps and records regarding your nearest harbor or waterway; reports of the United States Department of Commerce and Labor dealing with kinds and quantities of materials shipped by water from this harbor or on this waterway; reports or data from individual steamship companies regarding number of boats used, amount, nature, source, and destination of goods.

What to do. 1. Study the records listed above. From local merchants secure an estimate of the proportion of goods used which are shipped by water and the proportion shipped by rail.

Questions. If all water transportation to your community were discontinued, would the community suffer seriously? What kinds of goods are shipped more economically by water? by rail? How does time involved in shipping by water compare with time used in rail shipping?

Suggestions for report. Prepare a list of locally used materials which were shipped by water and give the source of each one.

Reference work. Read sections 169 to 172. Consult state and national records regarding kinds and quantities of imported and exported materials.

Optional problems. What influence did waterways have upon the establishment of New York City? of Philadelphia? of San Francisco? of New Orleans? of St. Louis? of Pittsburgh? of Seattle? What cities or towns of your immediate community are there whose location was affected by waterways?

PROBLEM 37

WATER SUPPLY FOR DOMESTIC AND INDUSTRIAL USES (XIV-1)

The problem. Our complete dependence upon water is brought clearly to mind whenever we are wholly deprived of it for a few hours or for a day. Its use in cleansing and in cooking is almost constant. The importance of an adequate supply of good water is difficult to overestimate.

What to do. 1. If there is a municipal water system, visit the pumping station. Learn from what source the water comes, what precautions are taken to protect it from contamination or to purify it, whether tests of the quality of the water have been made, and how much is really known and how much assumed regarding its healthfulness.

2. Use the following outline as a basis of the study.

Source of Water

1. Is the water obtained from wells, springs, a river, a natural lake, or an artificial lake?

2. Is the water supply system under public control?

3. How far away is the source of supply?

4. Describe the reservoir. Do plants grow in or upon the water?

5. Do fish or other animals live in the water? Is fishing or bathing allowed in the reservoir?

6. Is the reservoir area guarded partially or completely?

7. Describe the character of the watershed as to area; kinds of sand, clay, or rock found; kinds of vegetation found; amount of land cultivated; fertilizers used on farm crops; density of population and methods of sewage disposal.

Methods for Transferring Water

8. How is the water brought from the source to the reservoir? from the reservoir to the houses?

9. What is the course and capacity of the chief water mains?

10. How is the water pressure maintained?

11. How is extra pressure for fighting fires secured?

12. Are pumps used? Is a standpipe used?

13. What is the water pressure at the average street level? at the top of the taller buildings?

14. What conditions tend to reduce the average water pressure?

15. What are the regulations concerning the use of water for sprinkling lawns?

Methods of Purification

16. What dangerous and harmless impurities may be found in the domestic water supply? Give the source of each and suggestions for removal or prevention.

17. Is the water purified? How?

18. Describe the purification system as to method, size, capacity, and efficiency.

19. What chemicals are used in the water?

20. How often is the water tested by experts?

21. Are household filters commonly used? Are they safe?

22. Has any disease ever been traced to the local water supply?

23. How is the purification of the water supervised?

Character of the Water

24. Is the water clear and without sediment?

25. Has the water any odor?

26. What methods can be used to determine whether the water is hard or soft?

27. What means are used to soften the water?

28. Does the water contain dissolved matter?

29. How is the water affected by local storms?

Consumption of Water

30. What is the total cost of the water-supply system?

31. What is the population of the community?

32. What is the per capita cost of the system?

33. How much water is used daily?

34. What is the annual cost of operation of the water-supply system? What is the per capita cost?

35. Are water meters used? Why?

36. What are the local water rates?

37. What does it cost to furnish water to your home for one month? to your school?

38. Should the per capita use of water be increased or decreased? How?

The Sewage System

39. What is the final destination of the waste water?

40. What is the course of the chief sewers?

41. Is there any possibility of the sewage contaminating the water source?

42. Is a sewage-disposal plant in operation? Describe the essential features of a sewage-disposal plant.

Suggestions for report. Make diagrams showing sources of local water supply, location of plants for securing and delivering water, mains to deliver water to a dwelling house or school.

Reference work. Read sections 174 to 180.

Optional problems. What are the chief methods of securing adequate water supply in other communities near you? in the leading cities of the United States? Is it better and more economical for each family to be responsible for its own water supply or for the community to do this for all?

PROBLEM 38

RELATION BETWEEN WATER SUPPLY AND HEALTH (XIV–2)

The problem. It was known that certain diseases could often be prevented by boiling all drinking water long before it was known that small living organisms cause disease. Effective means of securing a pure water supply for drinking and domestic use will prevent all diseases which are transmitted by water. Typhoid fever is the commonest water-borne disease, and hence the prevalence of typhoid fever is often taken as an index to the purity of a water supply. What does the local death rate from typhoid indicate about the character of the water supply?

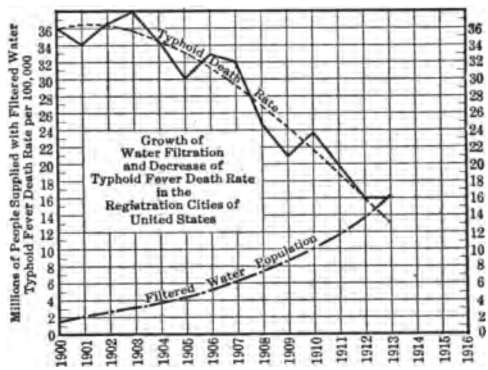


Fig. 28

(After Johnson and Tanner)

What to use. Data given on pages 161 and 165 of the text and that shown in figure 28; also, if possible, your local health officer's records regarding number of deaths from typhoid fever and the supposed or known sources of infection.

What to do. **1.** The relations which exist between water supply and disease and how purification of water reduces disease may be determined as follows: Plot on the graph which shows the statistics for Ottawa, Canada (Fig. 29), the facts for your local city if they are available.

Questions. Is typhoid fever a controllable disease? Is your local water supply from clean wells or lakes, and is it delivered into the homes and used in such ways as to insure that water is not a means of carrying disease germs? How does the quality of the local water supply compare with that of your neighboring communities?

Suggestions for report. Write the history of some particular case about which you can get the evidence to show how the failure to secure pure water resulted in disease.

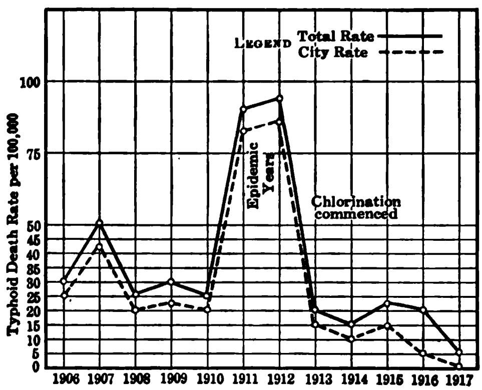


FIG. 29. Reduction of typhoid in Ottawa, Canada

(After Joseph Race)

Reference work. Read sections 175 to 179. Consult local records regarding relation of water supply to community and individual health.

Optional problems. How do the leading American and European cities compare relative to proportionate deaths from typhoid fever? How may any difference be explained? Are rivers likely to be the best source of water supply? What is the relation of flies to distribution of typhoid germs? Would there be danger of securing typhoid germs from flies if all typhoid material from persons ill with typhoid were sterilized? What are the reasons for a campaign to prevent the reproduction of flies? Can you prepare a series of large charts for an exhibit giving the facts on water supply and health?

PROBLEM 39

WATER SUPPLY AND SEWAGE DISPOSAL (XIV-3)

The problem. One of the greatest dangers to health is from the fact that when water is contaminated by sewage, disease germs from the sewage may be distributed. Water which is unclean is objectionable, but water which carries disease germs is intolerable. Modern communities are making great efforts not only to keep sewage from contaminating their water supply but to make use of the sewage.

What to use. Data and observations regarding the local plan for disposal of sewage; records or descriptions of the systems used in two or three of the large cities of the country. These records may usually be secured free by writing to the city health departments or water-supply bureaus.

What to do. Determine what system of disposal seems to insure noncontamination of the water supply and at the same time to make the best disposal of the sewage.

Questions. Does your community have a municipal sewage-disposal system? If so, describe the principal features. Are most of the houses connected with the system? Is it important that all should be connected? What is the final disposition made of the sewage? Is this disposition safe as far as your community is concerned? Does it menace the health of any other community? If there is no sewage system in your community, why not? Would the installation of one be an important public improvement?

Suggestions for report. Prepare a summary, stating the principal facts and needs of your community with reference to the proper disposition and use of sewage.

Reference work. Read sections 180 to 185.

Optional problems. What are the best means of securing freedom from sewage contamination in rural communities?

PROBLEM 40

HOW ARE MACHINES USED IN EVERYDAY LIFE? (XV-1)

The problem. The more intelligent races have developed the use of simple machines and combinations of them in the performance of work. In modern life almost no work is done without the aid of some mechanical device. The simple machines that are

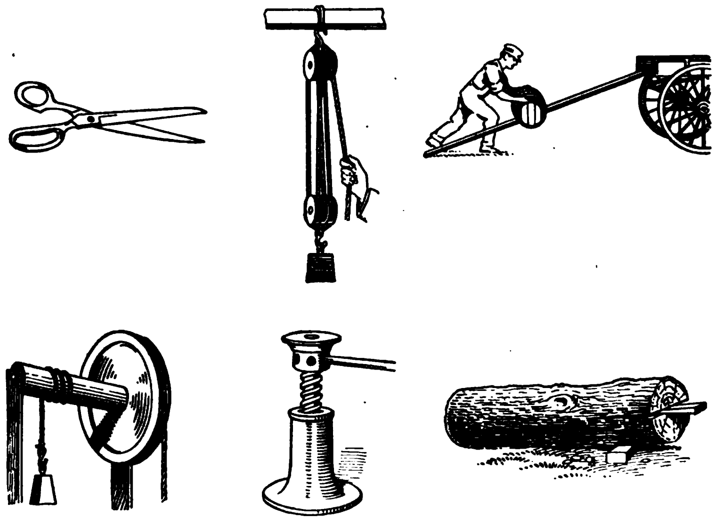


FIG. 30

commonly used are the lever, the pulley, the inclined plane, the wheel and axle, the screw, and the wedge. Where are these found in the community and how are they used?

What to use. The illustrations of the six simple machines shown in figure 30 and community applications of the same.

What to do. 1. Study the illustrations and applications carefully to understand the essential parts of each machine.

2. Prepare lists of the devices that you have seen which use the principles shown in the illustrations.

Questions. Are all the levers alike? What are the advantages and disadvantages of pulleys? What advantage is gained with the inclined plane? Is there any disadvantage in the use of the wheel and axle? Is there any similarity between the screw and the inclined plane? What advantage may be gained with the wedge? Which machine is most common in your community?

Suggestions for report. Make a drawing of one illustration of each machine from your list.

Reference work. Read sections 186 to 191.

Optional problems. Design and construct a model inclined plane, a wheel and axle, or any machine that you have studied.

PROBLEM 41

PULLEYS AND PULLEY SYSTEMS (XV-2)

The problem. The pulley appears in everyday life in a variety of forms. It may be the small wheel for a window weight or shade, or the large wheel for a derrick or elevator. It may be one pulley or a group of several with a single rope running over all. In every case the pulley or the combination of pulleys is used in order to secure a distinct advantage that cannot be easily secured in any other way. In order to use pulleys intelligently we ought to understand what the advantages are when used singly or in groups. How can this be done?

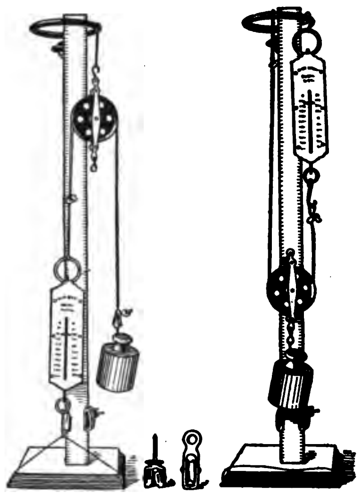


FIG. 31

What to use. Ring stand, ring, spring balance, weight, single pulley, cord, meter stick, and burette clamp.

What to do. 1. Set up the apparatus as shown in figure 31. Arrange the load so that it is supported by one cord. Weigh the spring balance itself and add this weight to the readings indicated by the pointer. What is the smallest reading that can be made on this balance?

2. Raise the balance slowly while holding the hook and note the reading. Lower the balance slowly and note the reading. Take the average of these values. Record all measurements on scrap paper for use in class discussion.

3. Next raise the load vertically 20 centimeters and note how far the force moves.

4. Arrange the apparatus so that two cords support the weight. It will not be necessary to add the weight of the balance to the scale reading, since the cord is fastened to the scale hook. Take a set of readings as suggested in 2 and 3. Complete the calculations given below under "Suggestions for report."

Questions. What advantage is gained in using a pulley with a single cord? Compare the force and load, the distance of the load and force, the work done in each case. Answer the preceding questions for 4. Compare the work done in the two systems. Account for the fact that more work is put into the machine than is obtained from it.

Suggestions for report. After a class discussion of the work, correct all mistakes and then record the measurements. Make a set of calculations for the experiment suggested in figure 91 of the text. This exercise should be demonstrated by the instructor.

CORDS	LOAD	AVERAGE FORCE	LOAD DISTANCE	FORCE DISTANCE	LOAD × DISTANCE $= A$	FORCE × DISTANCE $= B$	EFFICIENCY $= A \div B$

Reference work. Read sections 190 to 197.

Optional problems. Arrange a pulley system in which three cords support the load, and study it as suggested above. The approximate efficiencies of various machines are as follows:

	PER CENT
Reciprocating steam engines	8
Gas engines	17
Steam turbines	21
Oil engines	34
Water turbines	90

Can you make a bar diagram to show these facts graphically?

PROBLEM 42

WORK DONE IN CLIMBING STAIRS (XV-3)

The problem. It is very difficult to make a satisfactory numerical estimate of the work which one may do in pushing a lawn mower, sweeping, pumping water, or shoveling coal. The principal difficulty is in securing the necessary measurements of force and distance. However, it is not at all difficult to determine the amount of work done in climbing stairs, and this may be compared with other types of familiar work.

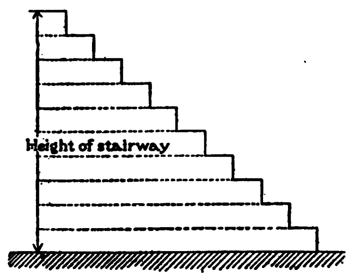


FIG. 32

What to use. Yard stick, pair of scales, and stop watch.

What to do. 1. Previous to the experiment each member of the class should be weighed and the weight recorded to the nearest pound.

2. Measure the vertical distance (Fig. 32) from the bottom to the top of a stairway. Record in feet and tenths of feet.

3. Using the data secured in 1 and 2 calculate the number of foot pounds of work done by each member of the class in making the climb.

4. Let each member of the class actually make the climb up a stairway, walking at the usual rate, while others note the time consumed. Enter the data in the table and make all of the calculations suggested.

Questions. What factors are necessary in order to measure work? How do the rates of work compare with each other? If one horse power is equal to 550 foot-pounds of work per second what is your rate in this experiment? If a man works at the rate of one-seventh horse power, what is your rate in "man power"? What horse power would be required to operate an elevator lifting

the entire class at the average rate? Is it wise to run upstairs and use energy at a very rapid rate? Make a calculation to test your conclusion.

Suggestions for report. Record all of the corrected calculations in a table and find the average horse power for the entire class.

Force (Weight)	Distance (Height of Stairs)	Work (Force × Distance)	Time (Seconds)	Foot Pounds per Second	Horse Power (1 H.P. = 550 ft. lb. per Second)

Reference work. Read sections 193 to 196, 198, and 200.

Optional problems. What would be the efficiency in your case if you should carry 25 pounds to the top of the flight of stairs? Count the work done on the 25-pound load as useful work.

PROBLEM 43

THE STEAM ENGINE (XVI–1)

The problem. The steam engine is a device for transforming the expansive force of steam into mechanical motion. These engines are usually classified according to the nature of the mechanism, to the manner in which the steam is used, or to the use to which the engine is put. Few inventions have influenced

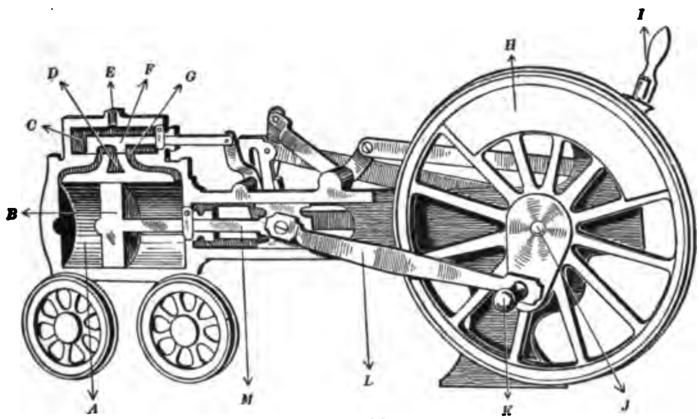


FIG. 33

modern life more than the steam engine. Land and sea transportation, the manufacturing industries, and the generation of electric power are all dependent upon the steam engine. How does it operate?

What to use. Ring stand, two rings, flask, jet tube, gauze, Bunsen burner, one-hole rubber stopper, pulley, and a model of a locomotive. If the model is not available use figure 33.

What to do. 1. By reference to your previous experience, a textbook in physics, a cyclopedia, or any other source, determine the ordinary names of the different parts of a steam engine and write these names near the proper letter in figure 33.

2. To see how the expansive force of steam may be transformed into motion, place a paddle wheel above a jet tube which is inserted in a flask (see Fig. 21). A suitable wheel can be made by cutting a metal pulley so that flanges may be turned aside. Heat the water in the flask until a vigorous jet of steam causes the wheel to spin. See if you can regulate the rotation of the wheel by changing the quantity of gas burned.

3. Next study the locomotive model as follows: Rotate the flywheel clockwise and bring the crank pin directly below the crank shaft (Fig. 33). Slide the reversing lever to the extreme right, and make a cross-section drawing of the cylinder and steam chest. Show the path of the live steam, the path of the exhaust steam, the direction of motion of the piston, and the forward or backward movement of the locomotive.

4. Rotate the crank pin clockwise one fourth of a revolution and repeat 2.

5. Rotate the crank pin an additional 90 degrees and repeat 2.

6. Study the model and arrange the locomotive to run in the opposite direction.

Questions. Trace all the changes from the burning gas to the spinning paddle wheel. What is the purpose of the slide valve? of the steam chest? How is the slide valve operated? Why has the flywheel a heavy weight? What is the purpose of the reversing lever?

Suggestions for report. File all of the drawings and written work in the notebook.

Reference work. Read sections 202 to 210. Make a list of the different types of steam engines that you have seen in operation.

Optional problems. Can you design and construct a small steam engine? Move the reversing lever to the left and work out 2, 3, and 4 as given.

PROBLEM 44

HOW DOES A FLASHLIGHT OPERATE? (XVII-1)

The problem. The electric flashlight has been called the modern candle. As a constant source of light it is rather expensive to operate. Nevertheless, the great convenience and safety of the device contributes to its popularity. Many thousands of small dry cells are used for flashlights every year. The manufacture of miniature lamps has been greatly increased by the development of the flashlight. How is this appliance constructed and how does it operate?

FIG. 34

What to use. Flashlight, magnifying glass, connecting wire (copper), hammer, and shears.

What to do. **1.** Remove the battery of dry cells and the lamp from the case. Examine the switch to see how it closes and opens the circuit. Make a cross-section drawing showing the path of the current from one terminal of the battery through the switch, lamp, etc. to the other terminal.

2. Study the construction of the lamp with a magnifying glass. How does the current enter and leave the small filament?

3. Use a hammer to remove the wax from the tops of the cells. How is the carbon of one cell connected to the zinc of another? How many cells do you find? Connect a wire to the carbon of the first cell (Fig. 34) and to the zinc of the third, and light the

lamp. Make a diagram showing the direction of the current from cell 1 through the lamp and each cell back to cell 1.

4. Test the lamp with two cells, and with one cell.

5. Disconnect the three cells. Join all the carbons with one wire and all the zincs with another (Fig. 34). Light the lamp. Make a diagram showing the path of the current from cell 1 through the lamp and each cell back to cell 1.

6. Cut the zinc so as to show the inside of the cell, and compare the parts with figure 98, *A*, of the text.

Questions. What are the essential parts of an electric circuit? Is a fuse used here? Why? In what direction does the current flow in the circuit? in the cell? Answer the questions in 2 and 3. How are cells connected in series? in parallel? Which is used here? Why?

Suggestions for report. File the corrected drawings in the notebook.

Reference work. Read sections 211 to 216.

Optional problems. Make a study of a different type of flashlight.

PROBLEM 45

HOW IS THE COST OF ELECTRICITY DETERMINED? (XVII-2)

The problem. As a source of heat and light electricity is more expensive than gas or kerosene, but there are compensations in the form of efficiency and cleanliness. Because of these advantages the use of the electric current in the house is increasing. In order to determine the cost of the energy used, the company usually installs a watt-hour meter, which is read at regular intervals by an agent of the power company. These readings are used as a basis of the bill which is sent to the consumer. **How are** these readings obtained?

What to use. The electric meter of the home, school, or store; figures 101 and 102 of the text; and blank forms for meters.

What to do. 1. Study carefully sections 219 and 220 in the text. Learn how to read the watt-hour meter (Fig. 35) and how to compute the bill for the month.

2. Read the meter on the same date of each month and enter the positions of the pointers in the circles. Find the local cost per kilowatt and compute the cost per month. Record the number of lamps and other electric devices in your home.

Questions. Tell how to read the meter. What mistakes are easily made? What is a kilowatt? a kilowatt hour? Can you estimate the average energy used per hour for each lamp and compare this with the values given on page 212 of the text? What are the sources of excessive light bills?

Suggestions for report. Complete all calculations and enter the correct values for a final record.

Reference work. Read sections 221 to 225. Secure the monthly electric bills for one year from a home, school, or shop, and make a bar diagram showing the values for each month during the year.

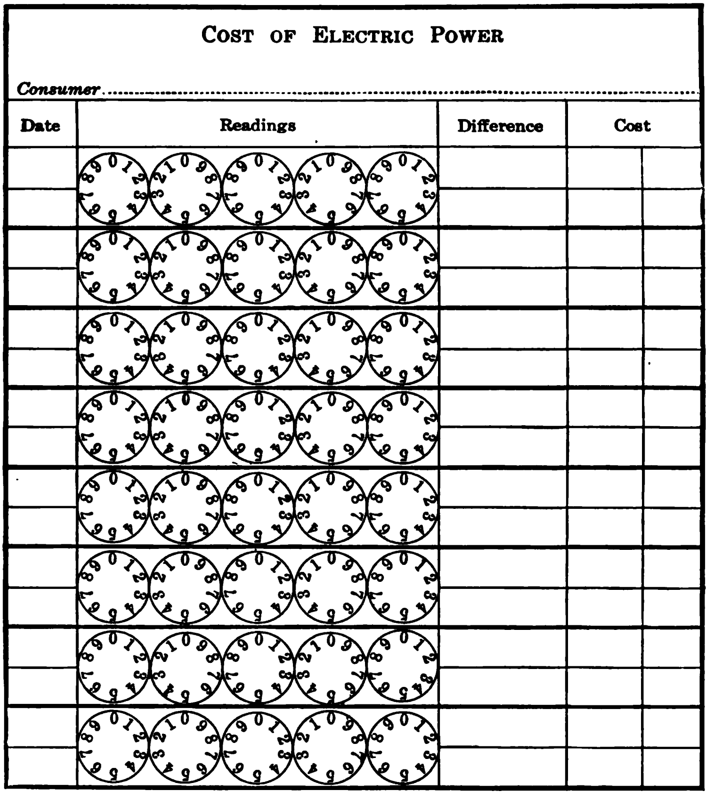


FIG. 35

Optional problems. Construct a large mechanical model which can be used for demonstrating how to read a watt-hour meter. Make a list of the motors in the school building, giving the information found on the name plate. What is the total horse power?

PROBLEM 46

PERMANENT MAGNETS AND THEIR USES (XIX-1)

The problem. Permanent magnets are now used for compasses, tack hammers, telephone magnets, toy magnets, ammeters, voltmeters, and magnetos. What characteristics make such magnets useful in these devices?

What to use. Ring stand; burette clamp; two bar magnets; box of scrap iron, tacks, iron filings and other materials; stick of wood; string; plate of glass; wood supports; and an iron pan.

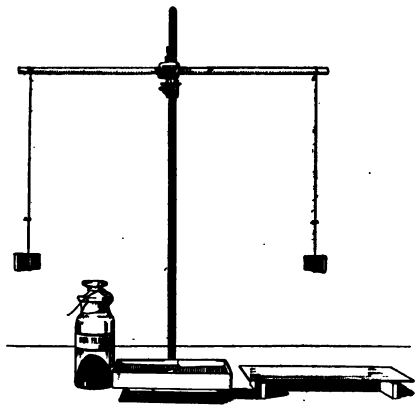


FIG. 36

What to do. 1. Put the bar magnet into the box of small objects. Remove the magnet and make a list of the substances that are attracted to it. Find the parts of the magnet which attract the most filings.

2. Place a small nail on a piece of glass and move the magnet under the glass. Try this with cardboard and iron.

3. Suspend two bar magnets as shown in figure 36. Mark the ends which point to the north. Remove one magnet and bring the north poles near each other. Try the other combinations suggested below. Record your observations.

4. Lay the bar magnet under the glass as shown in figure 36. Place a piece of paper over the glass and sift iron filings over the paper. Tap the paper gently until lines of filings appear. Make a drawing of the magnet and the lines. Mark each pole as north or south, as the case may be.

5. Place two north poles near each other under the glass. Repeat 4.

6. Repeat 5 with a north pole and a south pole near each other.

Questions. Where are the poles of a bar magnet? Where is the attraction strongest? weakest? Will a magnet exert an influence through all substances? What is the rule for magnetic attraction and repulsion? How is a compass made? What is the condition of the region about a magnet as shown by the iron filings?

Suggestions for report. Correct all errors, then file your results and drawings in the notebook.

NORTH TO NORTH	SOUTH TO SOUTH	NORTH TO SOUTH	SOUTH TO NORTH

Reference work. Read sections 231 to 234.

Optional problems. Can you make a compass out of a needle or a watch spring? Make a map of the magnetic field about any of the magnets suggested above.

PROBLEM 47

HOW DOES AN ELECTROMAGNET OPERATE? (XIX–2)

The problem. The electromagnet, discovered by Joseph Henry, has proved to be a highly useful device. The telephone, telegraph, electric bell, door opener, arc lamp, motor, and dynamo would not be possible without this mechanism. In learning how to make and operate an electromagnet we shall begin by studying the magnetic action of the coils of an electric bell.

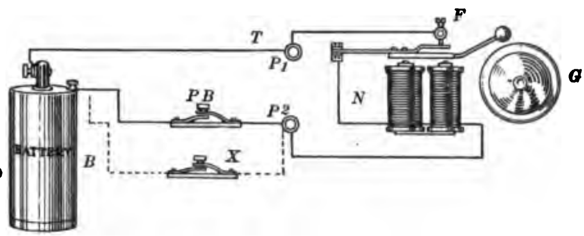


FIG. 37

What to use. New dry cell, push button or switch, four feet of No. 18 copper magnet wire, iron filings, compass, large nail, and buzzer or electric bell.

What to do. **1.** Connect an electric bell or buzzer to the dry cell as shown in figure 116 of the text. Remove the cover and study the action as follows: Note the insulation, set screw, spring, and magnet coils. Send a current through the circuit and watch the action. Write a brief explanation telling how and why the bell works.

2. Arrange the apparatus as shown in figure 37 and perform the experiment given in section 234 of the text.

3. Test a large nail for magnetism by the use of iron filings and a compass. If the nail is magnetized, reject it and try another. Wind 20 or 30 turns of the wire on the nail. Send a current through the coil and test the nail for magnetism with iron filings

and a compass. Mark the north pole and the direction of the current through the coil. Reverse the dry-cell connections and again test the poles of the nail.

4. Remove the nail from the coil and repeat 3. Write a rule for telling the relation between the direction of the current in the coil and the north pole of the coil.

Questions. Explain why the electric-bell clapper vibrates when the circuit is closed. What is the purpose of the set screw? How are the magnet coils connected? What causes the spark? Will the bell give an electric shock? How would you show that a current in a wire produces a magnetic effect? Can you state a rule from 2? How does a current in a coil affect the iron core? What is the effect of reversing the current? removing the iron core? How can you find the north pole of a coil when the direction of the current is given?

Suggestions for report. After a class discussion of the experiment write correct statements for all explanations and questions given above.

Reference work. Read sections 233 to 237. Make a list of all the devices you have seen in which an electromagnet is used.

Optional problems. Arrange an electric bell to be rung from either of two push buttons. Connect one dry cell, two bells, and two push buttons to form a street-car-bell circuit. Make a diagram to explain the electric circuit of an elevator annunciator.

PROBLEM 48

HOW DOES THE ELECTRIC MOTOR OPERATE? (XIX–3)

The problem. Among other advantages the electric motor has a wide range of speed, few parts, cleanliness, and less danger of accidents. Motors are used in the home to operate washing-machines, vacuum cleaners, and other appliances. In industry the motor is used to operate lathes, cranes, printing presses, tool-grinders, and many other machines. There are motors which are adapted for direct-current and alternating-current circuits. We shall examine a very simple motor which can be operated by a dry-cell battery.

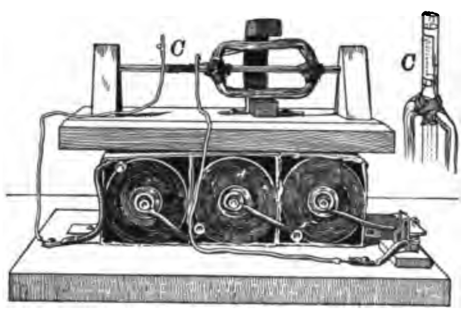


FIG. 38

What to use. Three dry cells connected in series, push button or switch, U-magnet, pliers, two pieces of No. 18 copper wire two feet long, screw driver, two pins, piece of capillary tubing six inches long, rubber tape, copper strips, ten feet of No. 24 magnet wire, and a wood frame shown in figure 38.

What to do. **1.** Construct the apparatus shown in figure 38.

2. Connect the dry-cell battery to the two copper wires and close the switch. Hold the ends of the wires on the copper strips as shown at *C* in figure 38. Adjust the copper strips until the coil revolves rapidly on the pin supports.

3. Reverse the battery connections and repeat 2.

4. Arrange the apparatus as in 2, reverse the poles of the U-magnet, and operate the motor.

Questions. What are the essential parts of a motor? Why is the permanent magnet used? What kind of magnets are used in

commercial motors? What is the purpose of the commutator on the motor? What is the effect of reversing the direction of the current through the coil? What is the effect of changing the poles of the magnet?

Suggestions for report. Make a cross-section drawing showing the direction of the current, the position of the poles, and the direction of rotation for 2, 3, and 4.

Reference work. Read sections 237 to 242. Make a list of the uses of motors with which you are familiar.

Optional problems. Can you find a better design for a small model of a motor than that given in figure 38? Bring to school any motors you own, study their operation, make drawings, and explain the operation to the class. Can you make an electric generator of the motor used in this experiment? Study the motor shown in figure 119 of the text and find how to make a series, shunt, or compound-wound motor.

PROBLEM 49

THE MOON'S CHANGE IN APPEARANCE (XX-1)

The problem. Primitive peoples noted the regularity of the moon's changes and measured time by them. The moon receives its light from the sun and reflects a portion of this light to the earth. We recognize the new moon as a thin crescent and the full moon as a brilliant yellow disk. Why do these changes occur? In seeking an answer to this question it will be best to find first the order in which the changes occur. This is done by keeping a record of the actual appearances of the moon on successive evenings.

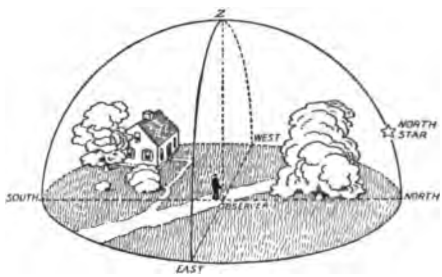


FIG. 39

What to use. The blank form suggested on the following page will be useful in keeping the record. It is best to make the observations at least one month before the final class discussion of the subject.

What to do. 1. Refer to a calendar to find when the moon is new. Look for the moon in the evening sky and record the facts suggested in the table on the following page. Estimate the altitude (Fig. 39) in degrees, the distance from either north or south to *Z* being 90 degrees. A convenient "yardstick" for measuring the sky may be had by considering the distance across the Big Dipper's bowl as 10 degrees.

2. Make as many observations as you can during the month (at the same hour if possible) and record the facts.

3. Assemble the records of the class and compare observations. Make large drawings showing the appearance of the moon at the age of four days, eight days, fourteen days, and twenty days.

Compare these drawings with the photographs found in figures 123 and 124 of the text.

Questions. In what direction from the sun was the moon when first seen? Does the moon rise and set at the same time every night? Where does the full moon appear at sunset? How many days intervene between new moon and full moon? How long will it be before the next full moon? Why does the moon change its appearance from evening to evening?

Suggestions for report. Record the observations in the table.

PLACE	DATE	TIME	DIRECTION OF MOON FROM OBSERVER	ALTITUDE (DEGREES ABOVE HORIZON)	DIAGRAM SHOWING SHAPE

Prepare a drawing similar to figure 39 showing the path of the moon across the sky, from new moon to full moon. Use the position of the moon at the same hour each evening.

Reference work. Read sections 248 to 255.

Optional problems. Look at the moon with a pair of opera glasses, a pair of field glasses, or a small telescope. Compare your observations with the outline map of the moon in case a well-illustrated textbook on astronomy is available. Devise a demonstration to explain the phases of the moon. Prepare a diagram to show why the moon rises later every night.

PROBLEM 50

THE PLANETS OF THE SOLAR SYSTEM (XX-2)

The problem. Next to the moon the planets are the most readily observed. In all, eight planets, of which the earth is one, revolve about the sun. Like the moon, the planets are observed by means of light reflected from the sun. The seven other planets which revolve about the sun move in the same direction as the earth and in almost the same plane. How many and which planets are visible at this time of the year?

What to use. The *Monthly Evening Sky Map* * for the current month or a "star and planet chart."

What to do. 1. Find what planets are visible this month. This is best done from the printed information mentioned above, but some almanacs and the first issue of the month of the *Scientific American* give these facts. Look for the planets in the proper positions in the sky and make one observation and record each evening. Continue observations for two or three weeks if possible.

2. In order to appreciate the relations of the planets to one another and to the sun, a model of the solar system can be arranged to scale as follows: Refer to page 253 of the text and record the names, diameters, and distances of the planets from the sun in a table. Record also the diameter of the sun, the diameter of the moon, and the distance from the earth to the moon. In choosing a scale let one millimeter represent 10,000 miles. Calculate the diameters of the sun, planets, and moon to this metric scale. Likewise calculate the distances of the planets from the sun. Convert this millimeter distance into feet (approximately) by dividing by 305.

3. Place a ball or a circle of the proper size in one corner of the room to represent the sun on this scale. Locate circles of the proper size and distance from the sun to represent the different planets.

*** May be secured at 150 Nassau Street, New York, 10 cents per copy.**

Questions. How can a planet be distinguished from a star? Does a planet rise and set? Does a planet change its position with reference to the stars? Can the planets be distinguished with the eye? Are all of the planets visible to the eye? What new facts do you discover through the use of the model?

Suggestions for report. Write a story in which you tell what you have done in 2 and 3. Choose some appropriate title relative to the planets and write the story in any form you desire.

PLACE	DATE	TIME	DIRECTION OF PLANET FROM OBSERVER	ALTITUDE (DEGREES ABOVE HORIZON)	DIAGRAM OF PLANET AND STARS NEAR IT

Reference work. Read sections 256 to 266.

Optional problems. Observe the planets with an opera glass, a field glass, or a small telescope and write a description of your observations. Where would the following appear in the model worked out in 2 and 3: Sirius (text, p. 273)? Mizar (text, p. 276)? Vega (text, p. 277)? Consult the *Evening Sky Map* for information on the moons of Jupiter.

PROBLEM 51

WHAT CONSTELLATIONS ARE VISIBLE THIS MONTH? (XXI-1)

The problem. Most people notice that the stars are grouped so that they form more or less conspicuous figures. The Big Dipper and the North Star are easily located. The Dipper is part of a larger group of stars called the Great Bear. Some of the larger stars in the more prominent constellations are easily located after they have once been pointed out to the observer. What conspicuous groups are visible now?

What to use. The sky map which is printed each month in the *Monthly Evening Sky Map* or the first issue of the month of the *Scientific American* will be the most convenient. A "star finder" can be used in the laboratory. Most pupils will find it wise to carry a small sky map so that observations can be made on any clear evening. A flashlight is useful for studying the map at night.

What to do. **1.** Secure the sky map for this month and mark on it the groups of stars that are to be located. Any of the important constellations mentioned in sections 275 to 278 of the text may be selected. If each pupil is not provided with a map, a large drawing should be placed on the blackboard, so that each pupil may copy it for out-of-door use.

2. Observe the sky each clear night until you have located the chief constellations. Do not try to locate too many groups the first few evenings. Do not be discouraged if you have trouble in making the map fit the sky. It is difficult to represent a hemisphere on a flat surface. Make a record of the observations.

Questions. Which constellations are most prominent? Locate the brilliant stars in these constellations. Do these stars rise and set as the sun? Do all the stars have the same color? the same size? Do you know the names of any of these stars? Does the Dipper move from hour to hour?

Suggestions for report. Make drawings of two important constellations as a part of the notebook record. Locate the groups on a figure similar to figure 39.

Reference work. Read Chapter XXI.

Optional problems. On a clear and moonless night focus a camera on the North Star. Expose the plate or film for three or four hours. Develop the negative and account for the curved lines on the picture. Make an observation of the Big Dipper every two hours during the entire night and keep a record of the observations. Explain the change.

PROBLEM 52

HOW ARE SOILS FORMED? (XXII–1)

The problem. It is thought that the earth's surface at one time was all rock or water and that fertile soil is of relatively recent origin. Almost all land regions and many water regions give some evidence of the ways in which soils are formed. A study of such regions to determine what is occurring will usually yield valuable information.

FIG. 40. Plant action in soil-making

Upper picture, lichens destroying rock; middle picture, a tree splitting a rock; lower picture, toadstools destroying an old stump, and leaves decaying and forming soil

What to use. The local stream beds and banks, hillsides, surface drains, exposed rocks with vegetation attempting to grow upon them, soil-survey reports bearing upon local soils, discussions of soils in library books and magazines.

What to do. 1. An excursion should be made into the adjacent country to study the soils. River-bottom lands, uplands, banks of streams, and walls of open ditches should furnish contrasting types of soils. Differences

in crops and in natural vegetation in correspondence with soil differences should also be observed. Visit a rocky ridge or ravine and study the formation of soil by weathering and plant action (Fig. 40). If the region is within a glaciated area, look for evidences of glaciation and formation of glacial soils (Figs. 139 and 140 in the text).

2. Find whether the region about the school has been surveyed by the Bureau of Soils, Department of Agriculture, Washington, D. C., and if so, secure a copy of the report. This will give maps and details regarding soil types of the region. The details of this study will vary with the locality.

Questions. Are there local areas of exposed rock in which you can find evidences of its disorganization to form soil? What effects do plants have in soil-making in rocky regions? Is there any evidence of glacial action? Does your community contain any glacially deposited soil and rock? Which type of soil in your community is considered most valuable? Why?

Suggestions for report. Write a brief history of the formation of the soil of your locality, giving specific local examples.

Reference work. Read sections 280 to 287.

Optional problems. How many types of soils are there in your locality? Can you determine the causes of the differences in these soils?

PROBLEM 53

THE MATERIALS OF WHICH SOIL IS COMPOSED (XXIII-1)

The problem. Soils differ so widely that even an amateur student can readily detect certain differences, and those who cultivate the land know qualities which may make a soil worth several hundreds of dollars per acre, or other qualities which may make it worthless. It is not hard to discover some of the qualities of soils, but others can be determined only by highly trained scientists.

What to use. Three or four pieces of glass tubing one-half inch in diameter and two feet or more in length (appendix, p. 178), cork stoppers, samples of three or four soils from the vicinity, and magnifying glass.

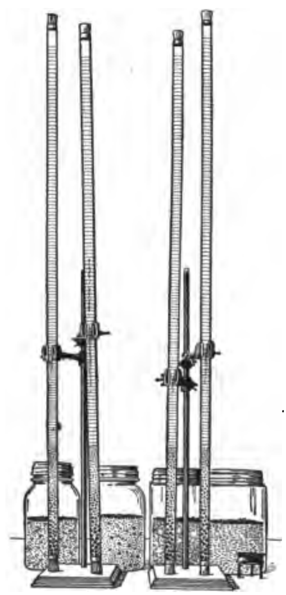


FIG. 41

What to do. 1. Close one end of each tube with a stopper (Fig. 41). Mix the soil sample with water so as to make a very thin mud, and pour into each tube enough of the mixture to make a layer six inches deep in the bottom of the tube. Then fill the tube with water. Close the upper end of the tube with a stopper. Invert the tube and watch the soil as it settles through the water

2. Examine the soil samples with a magnifying glass (Fig. 42) while the particles are settling in the water.

Questions. Which parts of the soil settle first and which last? How many and what kinds of materials can you detect in each soil? Does all the soil settle during one class period? in one day? Why? Do all soils contain rock and organic materials?

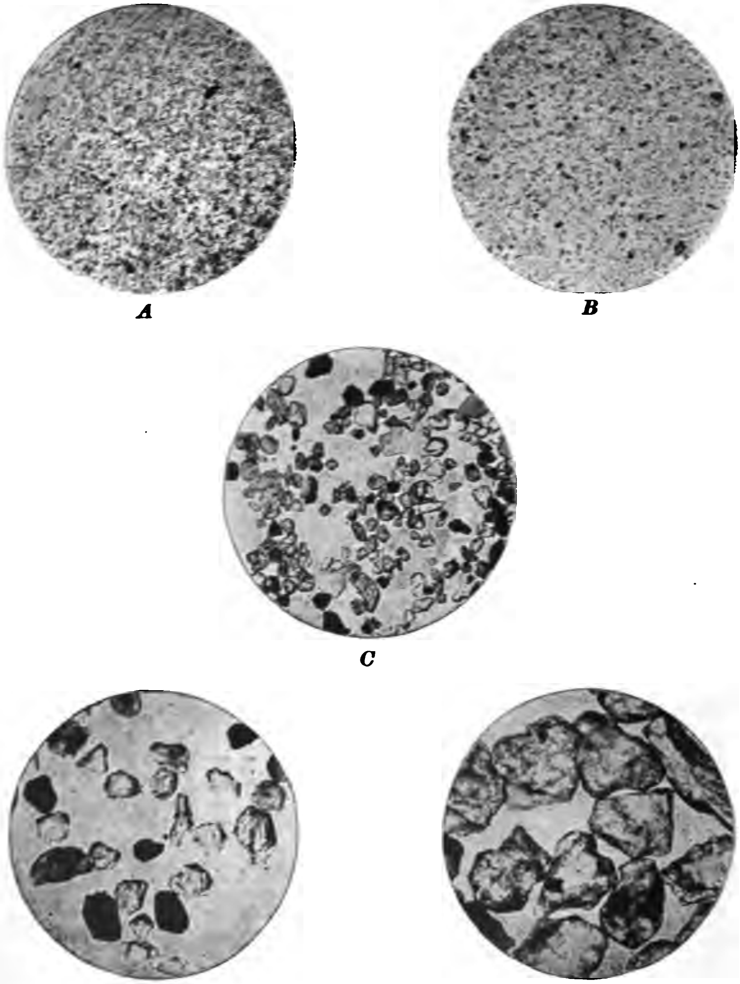


FIG. 42. Samples of the particles which compose soils

The size of the particles and the magnification used in these illustrations are given. *A*, clay, .005 – 0 mm. × 28; *B*, silt, .05 – .005 mm. × 28; *C*, very fine sand, .1 – .05 mm. × 28; *D*, fine sand, .25 – .1 mm. × 28; *E*, medium sand, .5 – .25 mm. × 28

Suggestions for report. Prepare a written description of the appearance and composition of the samples of soil examined.

Reference work. Read Chapter XXIII.

Optional problems. Does a fertile soil necessarily contain more or fewer of the finer particles than the poor soil? If a microscope is available, small pieces of soil should be studied under magnification. Prepare a set of soil tubes five feet in length for use in this experiment and set up the apparatus for a more prolonged experiment.

PROBLEM 54

THE ABILITY OF SOILS TO HOLD WATER (XXIV-1)

The problem. If sand, clay, and loam are all rained upon equally, they do not seem to be equally wet an hour or two following the rain. Similarly, if samples of each of these soils are

FIG. 43

soaked, then placed in the open air for two hours, they do not seem equally dry at the end of that time. How much water is present in ordinary soils?

What to use. Bunsen burner, iron pan, tripod, matches, spring balance (250-gram), samples of local soil, large spoons, iron wire, and forceps.

What to do. 1. Investigate the spring balance to make sure that it is working properly, since accurate measurements are necessary in this experiment.

2. Weigh the iron pan and record the weight. Put about 100 grams of the soil sample in the pan and weigh. Record the weight.

3. Put the pan on a tripod and warm it uniformly with a Bunsen flame (Fig. 43). Do not heat the soil so as to burn any material that may be in it. In fifteen minutes weigh the pan by lifting it with the wires. Record the weight. Warm the sample again and weigh every ten minutes as long as there is a loss of weight. Record the final weight.

4. While drying the soil sample, solve the typical example given in the table below to see if you can determine the per cent of water present in the assumed case.

5. After recording the final weight, empty the dry soil from the hot pan (forceps are convenient for this), take a new soil sample, and repeat 2 and 3.

6. Make all calculations suggested below.

Questions. How accurate is the spring balance? Is it best to have the soil in large pieces? Which sample loses the most water? the least water? What types of soil dry quickly in the sun? Why? What errors may easily occur in this experiment?

Suggestions for report. Record the corrected data and calculations.

Before drying Soil				After drying Soil			
Sample	Weight of pan	Weight of pan and sample	Weight of wet soil	Weight of dry soil and pan	Weight of dry soil	Loss of weight	$\frac{\text{Loss of wt.}}{\text{Wt. of wet soil}}$
Loam	40 g.	142 g.	102 g.	110 g.	70 g.	32 g.	31 per cent

Reference work. Read Chapter XXIV.

Optional problems. Glass tubes similar to those used in problem 53 may be filled with dry soil. The stopper at the bottom of the tube has a hole in it. Determine which soil sample holds the most water.

PROBLEM 55

WHAT MAKES SOIL FERTILE? (XXIV–2)

The problem. It is well known that a soil composed of pure sand, or rock, or clay, will not produce abundant crops. While a sample experiment, such as we can perform, will not enable us to identify all of the substances in a fertile soil, we may gain some information about it.

What to use. Dishes of dried soil from problem 54, metal pan, Bunsen burner or large alcohol lamp, tripod, spring balance (250-gram), iron wire, and forceps.

What to do. 1. Weigh the sample of dry loam soil in the metal pan. Heat the soil over a flame to a red heat and continue until all of the darker soil particles seem to have been burned. When cool, weigh again and record the results. Determine the per cent of weight lost.

Questions. Can you determine what the materials are which are burned in this experiment? Is any of the lost weight due to water? What methods do farmers use to enrich soils? What substánces do growing plants require?

Suggestions for report. Make the calculations suggested in the table.

After drying Soil			
Weight of dry soil and pan	Weight of dry soil	Loss of weight.	$\frac{\text{Loss of wt.}}{\text{Wt. of dry soil}}$

Optional problems. If soil is available from a sandy loam and from a peat bog make the above experiment with them and compare results. Place filter paper in a large funnel and wet the paper. Fill the funnel with a fertile soil. Pour distilled water through the funnel and note whether the water seems to dissolve any materials and carry them through the filter. By evaporating the water any substances dissolved may be discovered as a residue.

PROBLEM 56

HOW DOES EROSION AFFECT SOILS? (XXV-1)

The problem. Fertile soils contain much finely divided materials and much organic matter. These things are more readily washed away than are coarser soil substances. What are the effects of running water upon soils?

What to use. An open ditch, banks of a stream or lake, a city curb during or immediately following a heavy rain, an improvised stream over some soil in a well-drained sink.

What to do. 1. This study is best carried out by a visit to a running stream, a lake shore, or a hillside where ravines have been formed (Fig. 148 of the text). An open drainage ditch will usually furnish a good basis for this work. Observe the running water to determine whether it is carrying any soil particles.
2. Photographs should be made of all important examples of erosion.

Questions. Does rapidly running water carry more material or larger pieces than slowly running water? Where does the material come from? What becomes of this material? How does the carrying power of water change with changes in its rate of flow? What evidences upon this question are found along banks and riffles of lakes, streams, and ditches?

Suggestions for report. Make diagrams or photographs of one or more illustrations of erosion and describe what has occurred. Suggest a means for preventing erosion.

Reference work. Read sections 308 to 313, also bulletins or correspondence from your state agricultural college upon erosion in relation to soils.

Optional problems. Arrange an erosion model in a sink in the following manner. Fill one end of the sink with sandy or gravelly soil; close the outlet of the sink by use of a stopper

through which a short glass tube is inserted so that an inch or two of water will stand in that end of the sink before the water overflows; by use of a tube allow a small stream of water to run very slowly upon the soil farthest from the outlet. Observe the development of channels and the deposit of materials. If in an open field erosion is allowed to continue unhindered, what results will follow? Is it the better or poorer parts of the soil which are usually lost by erosion? Fill a glass jar or bottle with muddy water from a rapidly flowing stream and after a day or two see if any solid materials have settled from the water.

PROBLEM 57

HOW PLANT ROOTS ABSORB WATER (XXVII-1)

The problem. It is commonly said that plants cannot live without moisture. Water enters plants almost wholly through the roots. Can we demonstrate the entrance of water into plants?

What to use. Carrot (or beet) at least two inches in diameter and five or six inches long, one-hole rubber stopper, glass tube five feet long, apple corer, corn sirup, plastic clay, rubber bands, and quart jar.

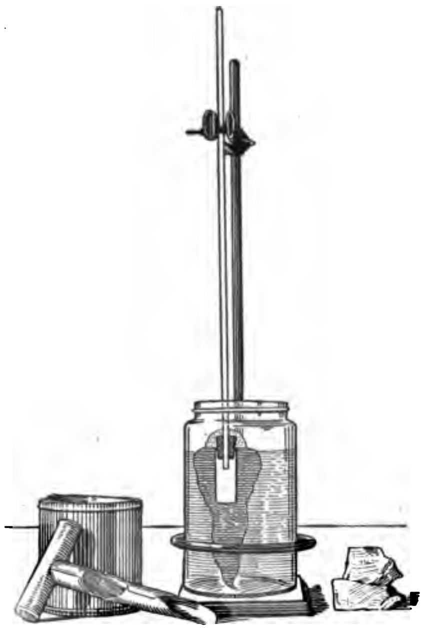


FIG. 44

What to do. 1. Bore a hole two inches deep in the top of the carrot (or beet) to fit the stopper. An apple corer is convenient for this work. Fill the hole half full with sirup. Add water, then stop the hole with the rubber stopper in which the glass tube has been inserted. Press some plastic clay around the stopper. Fasten the whole apparatus in an upright position (Fig. 44), the carrot being submerged in a jar of water almost to the stopper.

2. Observe and record hourly the rise of liquid in the tube.

Questions. Why was sirup placed in the hole in the carrot? If no sirup is placed in the hole and the carrot (or beet) is placed in a thick sirup instead of water, what results will follow?

Suggestions for report. Diagram the apparatus used and write a report in which you tell what was done, what happened, and how this experiment illustrates the action of plant roots.

Reference work. Read sections 319 to 325.

Optional problems. Cut off the top of a potted woody or semi-woody plant, cutting it about three inches from the soil. To the stump of the plant attach a small-bore glass tube in a vertical position. It is sometimes necessary to insure a tight joint by wrapping the rubber tubing with cord or wire. Water the soil freely and observe daily to see if water rises in the glass tube. Try the demonstration diagrammed in figure 156 of the text. Why is it that a grapevine when cut in the springtime "bleeds"? Do other plants act in the same way? When maple trees are "tapped," what is the source of the water which comes from the wound?

PROBLEM 58

WHAT ARE ROOT-HAIRS? (XXVII-2)

The problem. In the case of the carrot or beet used in the preceding experiment all of the smaller rootlets had been removed, but the remaining parts were still able to absorb water. Actively growing plants, however, secure almost all that water through very small outgrowths from the rootlet, known as root hairs. How can these root hairs be grown for observation?

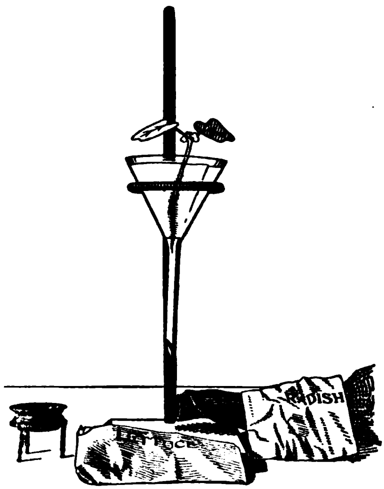


FIG. 45

What to use. Drinking-glass or funnel, filter paper, seeds of radish, oats, clover, or mustard.

What to do. 1. Cut a strip of filter paper four inches wide and two inches longer than the circumference of the glass at its top. Fold the paper lengthwise with each fold two inches wide. Turn, and crease one fold again, thus making a short fold each side of which is one inch in width. With a needle or pin perforate the crease of the short fold in many places, and place seeds in this fold. Place the filter paper with the wide fold innermost around the upper inner wall of the drinking-glass, allowing the ends to fit together. In case a funnel is used instead of a glass, the paper is folded and the apparatus set up as shown in figure 45.

2. Put some seeds between the filter paper and the glass. Fill the glass with sand or sawdust almost to the fold. Pour water

into the glass until the lower part of the wide fold is wet. The water will then cause the filter paper to adhere to the glass and moisten the seeds.

3. Observe from day to day, and as they develop, diagram and describe the roots and root hairs with reference to size, general appearance, length, diameter of hairs, location of hairs on roots, and abundance of hairs.

Questions. What differences are there in the length of root hairs on different parts of the rootlet? Are these differences due to differences in age?

Suggestions for report. Diagram the apparatus used and at least three stages in which the seedlings are sufficiently developed to show the root hairs. Write a complete description of the experiment and refer to the diagrams when necessary.

Reference work. Read sections 325 to 329.

Optional problems. If a microscope is available, mount some of the root hairs, together with the root from which they grow, and make a detailed study, showing the exact relation which exists between the root hairs and the surface cells of the root. Determine where the young root hairs are developing.

Stand freshly cut leafy stems in a red-ink solution. Very leafy stems, if placed in a sunny location with good circulation of air, may be ready for examination in half an hour. In many cases it will be well to allow the material to stand until the next day. Examine the stems by cutting across the stem at intervals or by peeling off the surface. If blanched celery, yellow coleus, or other light-colored plants are used, the stems will be sufficiently transparent to show the red color without cutting. Can the course of the solution be traced into the leaves? Are there definite tissues through which the solution passes? Diagram a cross section of the stem and a surface view of a leaf to show any points observed regarding definite tissues through which water passes.

PROBLEM 59

WHAT FOOD MATERIALS ARE PRESENT IN PLANTS? (XXVIII-1)

The problem. Plants provide food material not only for themselves but directly or indirectly for all other living things. It should prove interesting to determine what are some of the food materials to be located in some common plant substances.

What to use. Potato, rice, products of wheat, oats, or corn, test tube, Bunsen burner, test-tube stand, test-tube brush, iodine solution, test-tube holder, Fehling's solutions A and B, glucose (corn sirup), ordinary sugar, nitric acid, ammonia, teaspoon.

What to do. 1. *Starch.* Test the food sample for starch as follows: Crush some ordinary starch and boil it in a test tube. It is best to warm the tube slowly and uniformly at first. If the bottom of the test tube is heated too long at one time the glass may break or the water may suddenly boil over the top of the tube. When the solution cools add a drop or two of tincture of iodine solution. If a small amount of the solution is added a blue color will appear. If an excess is added the color will be black. Use this method in treating other foods.

2. *Glucose.* Test the food sample for glucose as follows: Pour into a test tube equal amounts (5 cc.) of Fehling's solutions A and B. Mix the solutions until a deep blue color is obtained. Heat this mixture almost to boiling and add a few drops of glucose (corn sirup). The red or yellow color shows the presence of glucose.

3. *Cane sugar.* Repeat the test given in 2, using some granulated cane sugar. Pure sugar will not produce the color changes observed in 2.

4. *Protein.* Crush the material and boil it in water. Add a few drops of concentrated nitric acid. **Caution:** If nitric acid comes in contact with the hands a rather permanent yellow color is

produced. A yellow color indicates protein. This color changes to orange by the addition of ammonia. Since plant proteins are not soluble the color will appear on the fragments.

5. *Fats and oils.* Put small pieces of the material, such as cheese or corn meal, on unsized paper and hold it above the flame so as to avoid charring the paper. A grease spot indicates fat.

6. *Mineral matter.* Place the sample in a teaspoon and heat in a draft until no more fumes are given off. Next burn off the carbon. The white ash remaining consists of compounds of various metals present in the food.

Questions. Is the iodine starch test a delicate test? Describe the changes in color produced by the glucose. Can the above kinds of foods be distinguished from one another by superficial observations?

Suggestions for report. Enter the results in the table below:

MATERIAL	STARCH	GLUCOSE	CANE SUGAR	PROTEIN	FAT	MINERAL MATTER

Reference work. Read sections 330 to 333.

Optional problems. Extend this work by testing other available plant foods.

PROBLEM 60

CAN STARCH BE DIGESTED OUTSIDE THE BODY OF A PLANT OR AN ANIMAL? (XXVIII-2)

The problem. Solid foods cannot be used for nourishment as solids. Plants and animals have many processes and methods of transforming foods so as to make them available for replenishing wasted tissues, for building new ones, or for providing energy for work. How is a solid food, like starch, changed into a soluble form?

What to use. Test tubes, starch paste, malted barley or barley grains, iodine solution, Fehling's solutions, mortar, filter paper, and funnel.

What to do. 1. Partly fill a large test tube or a cup with starch paste made by boiling a half teaspoonful of starch in a half pint of water.

2. Prepare a malt extract by grinding dry malted barley in a mortar or a coffee grinder, soaking one or two tablespoonfuls of the barley in a cupful of water for an hour, and filtering off the water, which with the substances in solution is the malt extract. If malted barley cannot be had, soak some fresh barley grains in water for from ten to twelve hours, pour off the water, and place the barley in a closely covered dish in a warm place to germinate. When the sprouts are an eighth of an inch long, crush the barley, soak in water, and treat as above.

3. To a test tube of starch paste add one or two cubic centimeters of the malt extract. Allow the mixture to stand for at least half an hour, preferably in a warm place. It may stand overnight with advantage. Test a small sample for starch. Test another sample for grape sugar.

Questions. What change has taken place as to the amount of starch present? of grape sugar? How do you account for these changes?

Suggestions for report. Write a brief summary of the facts shown by this experiment.

Reference work. Read sections 334 to 340.

Optional problems. Put some powdered starch in cold water in a test tube, add a small amount of malt extract and leave in a warm place for twenty-four hours or more. Test with Fehling's solutions to see if sugar is present. If a microscope is available, examine starch grains which have been acted upon by the malt extract and compare them with starch grains which have not been treated with malt. Do any of the grains show evidence that they have been partly digested?

PROBLEM 61

TRANSPORTATION OF DIGESTED FOOD IN ANIMALS (XXIX-1)

The problem. The blood serves as a carrying medium for taking materials to and from the tissues of the body. It is the indispensable transportation system in the human body, and it is worth while to know something about its nature.

What to use. Compound microscope, microscope slide and cover glass, vaseline, needle, and alcohol.

What to do. 1. This experiment should be prepared as a class demonstration. Sterilize a sharp needle by holding it in a flame for a few minutes. Wash the ball of the middle finger of the left hand with alcohol. Tie a piece of cloth quite securely around the first joint and then with a quick thrust of the needle puncture the skin. A drop of blood will quickly collect. This should be transferred to a glass slide. A cover glass which has had vaseline applied to its edges should be placed over the drop in order to seal it.

2. Place the slide on the microscope and observe first with a low magnification. Each pupil should observe the experiment under low and then under higher magnification.

Questions. Can you distinguish the liquid of the blood from the solid bodies (corpuscles)? What is the shape and nature of the corpuscles? In what parts of the blood is most of the coloring matter?

Suggestions for report. Write a brief description of the composition of the blood, using any references you have read to supplement your observations.

Reference work. Read sections 341 to 350.

Optional problems. Allow the arm to hang downward; grip the arm tightly above the elbow and note the location and appearance

of the veins of the lower arm. Then, releasing the pressure on the upper arm, hold the arm pointing upward and note the change in the appearance of the veins. Account for the difference. Place your finger on a prominent vein and note the appearance of the vein on both sides of the finger. Can you in this way determine the direction of the flow of the blood? Do you feel any pulse beat in the veins? in the arteries? What is your rate of pulse beat? Most of the arteries lie deep in the tissues, but they may be recognized by their "beat." Examine the right-hand wrist with the tip of the finger and locate the artery on the palm side of the wrist near the base of the thumb. Locate the arteries of both wrists. Count the number of beats per minute. Repeat to verify. Find also the carotid artery in the side of the neck, the small artery at either side of the nose just below the eye, and the artery just in front of the ear. What is the average number of heart beats per minute for your entire class? What are the greatest individual variations?

When an injury results in cutting a large blood vessel, how can you distinguish whether it is an artery or a vein? If an artery were cut at the elbow, where should the bandage be placed in order to stop the bleeding? If a frog is available his foot may be placed over the stage of a microscope so that the blood may be observed as it circulates through the capillaries. Trace the circulation of the blood as given in figure 161 of the text.

PROBLEM 62

THE COSTS OF DIFFERENT TYPES OF FOODS (XXIX-2)

The problem. Not many of the considerations with which men deal concern them more constantly than the values and costs of the different articles of food. Our food should contain proteins, fats, and carbohydrates, but the sources from which these things come may vary widely in their proportion to costs.

What to use. The food tables on pages 346 to 351.

What to do. **1.** Secure the current cost price of at least four common foods in each of the charts.

2. Diagram on the various charts in the text the proportionate costs and determine the kinds from which it will be most economical to select the needed types of foods.

Questions. Do you use the types of foods which provide proper nourishment at lowest cost? What reasons other than low costs cause some foods to be preferred to others?

Suggestions for report. Prepare a food chart which shows two economical foods from each of the five food groups given in the text charts. Use a different color for each of the five groups. File the chart in the notebook.

Reference work. Read sections 350 to 361.

Optional problems. Prepare a large food-cost chart for your community to show which foods will provide proteins, fats, and carbohydrates at lowest cost.

PROBLEM 63

THE DEVELOPMENT AND NUTRITION OF THE FROG (XXXI-1)

The problem. All plants and animals, no matter how large they may become, begin life as a single cell. In some the cell undergoes enlargement and new cells are formed by the division of the first cell, and this growth and division of cells continues throughout the entire life of the individual. In other cases a plant or an animal may consist of a single cell throughout its whole life, but these cells are extremely small and are not ordinarily observed.

What to use. Fresh eggs of the frog or toad (these may be secured in early spring from the pools of water in which they are deposited, the toad's eggs usually appearing a little later than those of the frog), large aquarium jars, and hand magnifying glasses.

What to do. **1.** Place the eggs of the frog or toad in an aquarium in shallow water. Observe them from day to day, noting early stages of development. Some of the eggs may be examined from day to day under the low power of a microscope. The following stages may be observed.

2. If the eggs are secured very soon after they are laid, it will be possible to see, with a hand magnifier or under the low power of a microscope, some which have divided into two cells, four cells, or a larger number of cells.

3. At a later period the original single egg cell has divided into such a large number that the individual cells of the mass cannot be separately distinguished by use of the magnifier.

4. The mass of cells produced by the egg becomes elongated instead of spherical. This is called the embryo.

5. The embryo continues to elongate; head and tail may be distinguished; eyes and other organs appear. Determine what the animal feeds upon at this stage and how it secures its food.

6. The young animal frees itself from the surrounding jelly, swims through the water, and usually attaches itself to floating objects or to the walls of the aquarium. At this stage it has conspicuous gills (breathing organs). Is the source of food and method of feeding the same in this stage as in the preceding one?

Questions. At what point in the division of the egg can you see the cells begin to be different from one another? How can you distinguish frogs' eggs from toads' eggs? In what kinds of situations do these animals lay their eggs? How many of the stages given in figure 170 of the text can you recognize? Upon what do adult toads and frogs feed? Are their feeding habits of any economic significance?

Suggestions for report. Record and describe all of the changes which you have observed in the development of the egg.

Reference work. Read sections 371 to 378.

Optional problems. Place the young tadpoles from the eggs you have collected in aquaria where they will thrive, and follow their development through several weeks to determine the nature, time, and order of the changes which occur as the tadpole is becoming a frog or toad. By varying the conditions in which the developing tadpoles are kept, determine the conditions which are best for their growth.

PROBLEM 64

DEVELOPMENT OF THE BIRD EMBRYO DURING INCUBATION OF THE EGG (XXXI-2)

The problem. The cell from which the bird develops is embedded within the food material of the egg. When the egg is fresh this cell is so small that most people fail to notice it, but soon after the incubation of the egg has started, the growth and division of the cell is such that it may be readily observed.

What to use. Two dozen hen's eggs and an incubator.

What to do. Place at least two dozen hen's eggs in an incubator which has previously been in operation until it is regulated. Open an egg on each of the following days of the incubating period: first day, second, third, fifth, eighth, twelfth, and sixteenth. On the first day note the germ cell, or fertilized egg, lying close to the yolk, it being recognized by a reddish ring about it. In the other observations determine what changes have taken place in the eggs.

Questions. Why will eggs usually not hatch after they have been subjected to sudden and great changes in temperature? Why will eggs not hatch after they have been in cold storage?

Suggestions for report. Prepare a set of sketches showing the general appearance of the developing bird at about five different stages between your first and last observations.

Reference work. Read section 378.

Optional problems. How do you account for the fact that in a nest of young robins the birds hatch on successive days, while in a nest of quail or domestic fowls the young birds usually all hatch on the same day?

PROBLEM 65

THE YOUNG PLANT (XXXI-3)

The problem. Some plants, like some animals, never become larger than a single cell and others grow until they contain millions of cells arranged in the form of different plant organs. The beginnings of a plant are as interesting as the beginnings of an animal.

What to use. Seeds of bean, corn, clover, or peanut; sawdust, sand, or common soil; earthen pots, or small wooden boxes which may be made by pupils.

What to do. 1. Plant seeds of bean, corn, or peanut at least two weeks before it is intended to make this study. If the seeds are planted near the glass side of a properly constructed box (Fig. 46), this side being darkened by the use of a black cloth, the growth may be observed during the process. Observe the plantings from time to time and record all facts of interest as the young plants develop. When the plants have from two to four leaves, make your final study and description. At this time the young stem and roots, as well as the leaves, will have assumed definite form, also their characteristic positions.

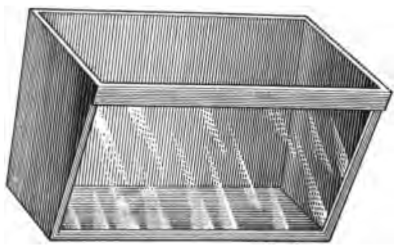


FIG. 46

2. Soak some seeds in water for about twenty-four hours and examine them to discover how many and what structures found in the seedling may be found also in the seed. Examine the seeds for evidence of stored food.

Questions. What is the function of the food stored in the seed? Is this food stored in the same kinds of places in different

seeds? How long can a plant live entirely upon the food that is stored in the seed? Could the young plant start its growth without stored food?

Suggestions for report. Prepare a series of sketches properly labeled illustrating the successive stages of growth of the plant.

Reference work. Read sections 379 to 385.

Optional problems. Plant ten or twelve different kinds of seeds, and as they grow determine the nature and variations in the seed leaves of the plants. By the use of a very sharp knife remove the seed leaves from some seedlings as soon as the seed leaves appear above the soil, and determine what effect this has upon the later growth of the young plants.

PROBLEM 66

OVERPRODUCTION OF PLANTS AND ANIMALS (XXXII-1)

The problem. New plants and animals are formed in such large numbers that until one has studied the matter carefully it is difficult for him to believe the facts about the numbers of new individuals that are produced. Any common plant or animal used as the basis of some simple calculations will show the possibilities of production of new individuals.

What to use. Ears of corn, heads of wheat or oats, seed pods of any common plants, data regarding number of eggs laid by a robin or by a toad.

What to do. 1. Determine how rapidly given plants or animals would increase in given lengths of time if all seeds should grow in the case of plants or if all the young of animals should mature. It is suggested that each pupil make but one or two of the calculations and that the results be made available to the entire class.

2. *Indian corn.* Count the rows and number of grains in a row of one ear. Estimate the number of grains on the ear. Calculate the descendants in the fifth generation, assuming that each grain produces a plant upon which one good ear develops.

3. *Wheat.* Ascertain the number of grains in a head and suppose that there are five heads to each plant. Calculate the number of grains in the fifth generation.

4. *Robin.* Assuming that a female robin will lay four eggs (though she may often lay eight in one year) and that one half of the new birds will be females, calculate the number of robins at the end of ten generations if all eggs hatch and no birds die.

5. *Toad.* A female toad may lay as many as 11,000 eggs in one season. Assuming that 8000 is a fair average and that one half the young toads will be females, calculate the number of toads from a single pair at the end of four generations if all eggs hatch and no toads die.

Questions. Do the numbers that you calculate indicate how many might come into existence if all really developed? In what ways do available food, space, light, and proper temperature affect the development of large numbers of new plants or animals? What illustrations in your immediate environment can you cite to show that there is a struggle for existence between the large numbers of new forms that are produced?

Suggestions for report. A summary of the calculations cited above should appear in the notebook.

Reference work. Read Chapter XXXII.

Optional problems. Assuming that an average toad will weigh a quarter of a pound, what would be the weight of the four generations of toads according to your calculation? Why do not plants or animals really increase as rapidly as indicated by the above calculations?

PROBLEM 67

VARIATION IN EARS OF CORN (XXXIII-2)

The problem. In the preceding exercise it became apparent that new individuals are produced in very great numbers. A brief study of these individuals would show that it is very difficult and probably not possible to find any two individuals that are alike. Such a study of ears of corn will prove interesting.

What to use. Enough ears of corn so that each pupil or each two pupils may have one ear as a basis for work.

What to do. 1. Each pupil should calculate the number of grains on one ear. In case grains have been lost, determine how many were lost and add this number to the number counted.

2. Write the total upon the board and also copy in your notebook the totals of all the other pupils. Underline the largest and smallest numbers, and find the average number.

Questions. Can you find two ears of corn that have exactly the same number of grains upon each ear? Do you think you could find any two grains that are exactly alike in every respect?

Suggestions for report. Record the numbers of grains found upon the ears of corn studied by all the members of your class and prepare a graph to show the number of ears having different numbers of grains.

Reference work. Read sections 395 to 400.

Optional problems. Do most of the ears used in the calculations come nearest to the smallest number, to the largest number, or midway between? If you were selecting one ear for planting from all those used in the calculations, which one would you select? What qualities led you to make your selection? Compare the grains and the cobs of the different ears studied. What percentage of the total weight of the ear is the weight of the grains?

PROBLEM 68

ARE VARIATIONS IN PARENTS TRANSMITTED TO OFF-SPRING? (XXXIII-2)

The problem. It is a matter of common observation that the young of one generation bear more or less resemblance to the parents, but also that they differ from the parents. Interesting studies have been made in the effort to cause these differences from generation to generation to develop along the line of certain specially desired qualities.

What to use. The table given on page 174 shows the height of 928 persons whose records were studied by Sir Francis Galton. It is so arranged that the heights of these individuals may be compared with the heights of their parents and the inheritance of stature may thus be seen.

What to do. 1. In the third horizontal space from the top the figure given indicates the size-groups in which the children are classified. The vertical column at the left (column 1) gives the heights of the parents, the heading "Mid-Parental Height" meaning the middle point between the heights of two parents in a family. In column 16 at the right the figures in each space represent the average height of all children of parents of the heights indicated in the corresponding space in column 1. The other figures of the table indicate the distribution of the children. The way in which the table is read is indicated by the following examples:

2. Column 3 shows that among the seven persons whose heights were near 62.2 inches there are three from families in which the mid-parental height was 67.5; three from families with a parental average of 66.5; and one from a family in which the parental average was 64.5.

3. Line *b* shows that in all the families in which the mid-parental height was 72.5 inches one child had a height, when adult, of about 68.2 inches; two were 69.2 inches tall; one was

70.2; two were 71.2; seven belonged to the 72.2 group; two belonged to the 73.2 group; and four were taller than any of these.

4. Examine line *f*. Observe and state how wide is the variation. Note how many children are taller than their parents, how

Mid-Parental Height		Heights of Adult Children														
1		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		61.2 and below	62.2	63.2	64.2	65.2	66.2	67.2	68.2	69.2	70.2	71.2	72.2	73.2	74.2 and above	Mean of Children
a	72.5 and above												1	3		72.95
b	72.5								1	2	1	2	7	2	4	71.4
c	71.5					1	3	4	3	5	10	4	9	2	2	69.9
d	70.5	1		1		1	1	3	12	18	14	7	4	3	3	69.5
e	69.5			1	16	4	17	27	20	33	25	20	11	4	5	68
f	68.5	1		7	11	16	25	31	34	48	21	18	4	3		68.0
g	67.5		3	5	14	15	36	38	28	38	19	11	4			67.6
h	66.5		3	3	5	2	17	17	14	13	4					67.1
i	65.5	1		9	5	7	11	11	7	7	5	2	1			66.8
j	64.5	1	1	4	4	1	5	5		2						65.6
k	63.5 and below	1		2	4	1	2	2	1	1						5.6

many are shorter, and how many are nearly of the parental height. Do you find that many of the children closely resemble the parents in height? Before you draw any conclusions study the lines *c* and *j*, and other lines, to see whether the relations you find in line *f* are generally true.

Questions. So far as you can determine by this study, what do you think about the probable average resemblance of a child to its parents? What are your conclusions about the likeness of the offspring to the parents?

Suggestions for report. The results of the observations called for under "What to do" should be recorded in your notebook.

Reference work. Read sections 400 to 406.

Optional problems. Compare the average heights of parents (column 1, *b* to *j*) with the average heights of their children (column 16). Find the difference between these figures in each horizontal line, marking the differences by the plus sign (+) if the children average taller than their parents, and by the minus sign (−) if they are shorter. Are the children of unusually tall parents, on the average, taller or shorter than their parents? Are children of unusually tall parents taller than the average of all children? Are any of them taller than their parents? Make the same study regarding the unusually short persons. In general, do the children of unusual parents average as unusual as the parents? If the rule of inheritance shown above holds good for such characteristics as mental ability, moral tendencies, tendencies toward insanity and feeble-mindedness, what is the advantage of being "well-born"?

APPENDIX

I. SUGGESTIONS FOR THE USE OF GLASSWARE, CHEMICALS, AND THE METRIC SYSTEM

NOTE. These directions are written to accompany the various pages of this manual as indicated in the notes below. The suggestions and tables appear in the order in which they will be needed in the problems as outlined.

NOTE 1 (p. 1). *How to break* (*cut*) *glass.* Ordinary glass tubing having a diameter of one-half inch or less may be cut as follows: Place the glass tube on the table and make a small notch at the desired point with the sharp corner of a triangular file. Next hold the tube in the hands with the thumb nails on the tube opposite the scratch. Pull on the tube and push with the thumbs. If the tube does not break easily make the notch deeper and longer.

NOTE 2 (p. 1). *The glass plug.* Secure a six-inch piece of glass tubing (Fig. 47, *A*) having an outside diameter of one fourth of an inch. Hold one end in the lower edge of the flame (Bunsen burner or suitable alcohol burner), rotate it slowly, and gradually bring the tube to the top of the flame. The pupil must remember that all glassware must be heated slowly and uniformly in order to prevent breakage. When the sharp edges of the tube become smooth (do not heat the glass until the hole is sealed) remove the tube, then treat the other end in the same manner.

When the tube has cooled, hold the ends between the thumbs and fingers and place the middle of the tube in the lower part of the flame; rotate the tube; move it back and forth in the flame; and gradually bring it to the upper part of the flame. Continue the rotation, and heat about one inch of the tube uniformly until it becomes soft (do not let it bend in the flame); then remove it from the flame and immediately pull the ends apart (Fig. 47, *B*) until the middle portion contracts to a diameter of approximately an eighth of an inch. Allow the tube to cool. Cut the tube in the middle of the narrow portion. Save one part for a jet tube (Fig. 47, *C*) and make a glass plug (Fig. 1) of the other.

Hold the small end of the tube in the flame until it is entirely sealed. This completes the two pieces shown in figure 47, *C*.

NOTE 3 (p. 1). *How to cut a large tube.* Make a deep scratch in the middle of the eight-inch test tube, then wrap a piece of wet paper

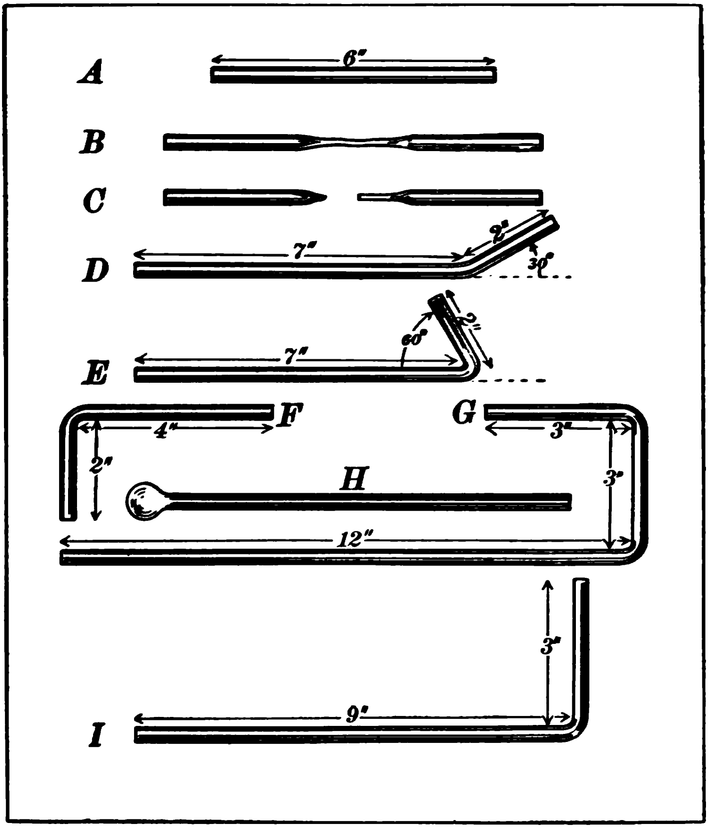


FIG. 47

several times around the tube on each side of the notch, leaving a small portion of the tube exposed. Put the tube in a narrow flame and keep the flame ahead of the crack by rotating the tube. A red-hot iron can often be used to advantage as a substitute for the flame.

NOTE 4 (p. 5). *The use of the jet tube.* In addition to the jet tube (Fig. 47, *C*) shown in figure 2 a long, straight tube is necessary. Secure a piece of glass tubing nine inches long and make the rough edges of each end smooth (this process is called fire-polishing) by heating each end uniformly in the flame.

NOTE 5 (p. 6). *Bending glass tubing.* Dry glass, if heated slowly to red heat, does not break but may be bent into almost any form. In order to make the two pieces for the wash bottle, two nine-inch pieces of glass tubing are required. The ends of each piece should be fire-polished and the glass allowed to cool. Next, heat one tube slowly and uniformly at a distance of two inches from the end. When the glass is soft enough to bend, remove it from the flame and bend it slowly into the form shown in figure 47, *D*. The bend should be gradual and the glass of uniform thickness. Avoid sharp bends with thin glass.

Heat the second piece of glass and make the bend shown in figure 47, *E*.

NOTE 6 (p. 9). *The metric system.* The metric system is used in all civilized countries with a few exceptions. The United States and Great Britain have not formally adopted it, but in these countries the system is universally used by scientists and is coming into use more and more by manufacturers, as shown by their catalogues. At the present time students need to know both the metric and English systems of measurement.

In the metric system each unit is ten times as large as the next lower unit; hence the system is often termed the "decimal system."

Units of length. The unit is the meter. It is equal to 39.37 inches.

10 millimeters (mm.)	= 1 centimeter (cm.)
10 centimeters	= 1 decimeter (dm.)
10 decimeters	= 1 meter (m.)
1000 meters	= 1 kilometer (km.)

The only metric measures of length ordinarily used in general science are the millimeter and the centimeter; thus, the height of the barometer at the sea level is recorded as 76 cm. (or more commonly as 760 mm.), and not 7 dm. and 6 cm.

Units of volume. The metric unit generally used is the cubic centimeter.

1000 cubic millimeters	= 1 cubic centimeter (cc.)
1000 cubic centimeters	= 1 cubic decimeter (1 liter)
1000 cubic decimeters	= 1 cubic meter

We shall use the cubic centimeter and the liter as measures of volume. Thus, the volume of a test tube may be given as 25 cc.; that of a flask may be given as 500 cc., or $\frac{1}{2}$ liter.

Units of weight. The metric unit is the gram. This is approximately the weight of 1 cc. of pure water at its temperature (4° C. or 39° F.) of greatest density. It is equal to 15.43 grains.

10 milligrams (mg.)	= 1 centigram (cg.)
10 centigrams	= 1 decigram (dg.)
10 decigrams	= 1 gram (g.)
1000 grams	= 1 kilogram (kg.)

The gram and kilogram are the units of weight most generally used. Thus, the weight of an object may be given as 10.5 g. and not 10,500 mg. or 10 g. 5 dg. 0 cg. 0 mg.

Note that:

1 pound troy (5760 grains)	= 373.24 grams
1 pound avoirdupois (7000 grains)	= 453.59 grams
1 ounce avoirdupois	= 28.35 grams
1 U.S. liquid quart	= 946.36 cubic centimeters
1 inch	= 2.54 centimeters
1 meter	= nearly 1.1 yards
1 kilogram	= nearly 2.2 pounds avoirdupois

NOTE 7 (p. 9). *How to weigh.* 1. See that the scales are level and the pans clean. Move the sliding weight of the beam to the zero mark on the left side.

2. To find whether the scales are balanced, cause the pointer to swing back and forth across the middle mark of the scale. If the pointer swings approximately the same number of divisions on each side of the middle mark, the scales are probably balanced. Use the set-screw if the scales are not balanced.

3. Place the article to be weighed on the left pan, in the center, if possible.

4. Put the weights on the right pan, starting with one which is too large. Next, find a weight that is too small, then make the necessary adjustments. Use the beam and sliding weight for all weights less than ten grams. The small divisions on the beam are tenths of a gram.

5. Balance the scales, then add the weights to obtain the total, and check to avoid errors. Return the weights at once to the block and leave the scales ready for use.

NOTE 8 (p. 9). *The right-angle bend.* A good right-angle bend, as shown in figure 4, is not easy to make unless one is willing to be patient and careful. It is usually best to use a flat flame produced by a wing-top, or fishtail, attachment for the burner. If this does not give a

uniform flame, it is best to use the ordinary flame and heat the tube by moving it back and forth through the flame as the tube is rotated. When the glass is heated so that it bends easily, remove it from the flame and bend it slowly to form a right angle (Fig. 47, *F*). If the tube begins to flatten at the bend, warm it and try again. Nonuniform heating and too rapid bending are the chief difficulties to avoid. Fire-polish the ends and set aside to cool. Save this right-angle bend for future use.

NOTE 9 (p. 9). *The U-tube.* Construct this tube by making two right-angle bends in the middle of a tube five feet long. A right-angle bend should be made near one end before the U-tube is constructed. See figure 47, *G*, for suggestions. Fire-polish the ends of the tube when it is complete.

NOTE 10 (p. 13). *Construction of a small funnel.* The small funnel shown in figure 5 is made from a four-inch test tube. Follow the suggestions given in Note 2, and draw out the tube as shown in figure 47, *B*. The glass can then be cut with a file.

NOTE 11 (p. 23). *To remove the bottom from a bottle.* To remove the bottom from the bottle shown in figure 8, the suggestions given in Note 3 should be followed.

NOTE 12 (p. 27). *To make a glass bulb.* First seal a tube which has a small inside diameter. Next, heat the tube until it becomes quite soft, remove it from the flame at once, and blow cautiously into the tube. The bulb will begin to form. Warm the tube again and repeat the blowing process until a bulb is obtained which is spherical and of uniform thickness (Fig. 47, *H*). If the bulb becomes irregular, heat the glass until it contracts to a small mass, and begin again.

NOTE 13 (p. 47). *Working heavy glass.* The bottle shown in figure 14 can be obtained by removing the bottom from a quart milk bottle, as suggested in Note 3. It may be necessary to spoil two or three bottles, but one is often successful with the first one if a hot iron is used.

NOTE 14 (p. 47). *How to handle chemicals.* 1. In pouring chemicals from small glass-stoppered bottles, the flat portion of the stopper should be held between the second and third finger of the right hand. Glass stoppers should not be placed on tables, as this often causes the chemicals to get on the clothing.

2. Concentrated sulfuric acid is a heavy, oily liquid which is one of the most difficult chemicals to handle. It does not evaporate rapidly, and it is exceedingly active chemically. It chars wood, makes holes in the clothing, and has great ability to extract water from substances. *Water should not be poured into the acid.* With this information one can exercise the proper precautions and use the acid with no difficulty.

3. If chemicals are spilled on the table or floor, they should be cleaned up at once. Acids can be neutralized with baking soda.

4. Concentrated hydrochloric acid is a gas (hydrogen chloride) dissolved in water. There is no particular difficulty involved in its use.

5. Concentrated nitric acid must be handled with care. It is a very active substance which dissolves many metals (with the liberation of brown fumes) and also produces bad burns if allowed to come into contact with the skin.

6. Do not return unused chemicals to the original bottle. All of the pure material may be spoiled by impurities taken up by the unused chemicals.

7. Report breakage at once to the instructor.

8. Take no materials from the laboratory without special permission.

9. Do not make promiscuous mixtures of chemicals to see what will happen.

10. Do not begin experiments of your own devising without permission from the instructor.

NOTE 15 (p. 59). *Use of the compound microscope.* The compound microscope is a very delicate instrument which should be used only with a knowledge of the proper care of the various parts. Pupils should not play with this instrument. A booklet of directions is furnished with each microscope. Pupils can learn how to use the instrument from the booklet, but should obtain permission from the instructor for any special observations they wish to make.

NOTE 16 (p. 65). *Tubing needed for the yeast experiment.* The tube shown in figure 19 is made from a piece of tubing eighteen inches long. Two right-angle bends are made, as shown in figure 47, *G*. The ends should be fire-polished also.

NOTE 17 (p. 79). *The siphon.* The glass tubing shown in figure 25 can be made from two pieces, each twelve inches long. A right-angle bend should be made in each piece near the end, as shown in figure 46, *I*. The ends should be fire-polished.

II. LIST OF APPARATUS

EXPLANATORY NOTE. In the following apparatus lists Part I includes articles most of which, if secured, must be purchased from laboratory-supply companies. Part II includes articles most of which can be secured from the school, home, or environment. Homemade apparatus is advised when it is possible to make it. Much of the apparatus can be made with educational advantages in coöperation with other departments of the school, as industrial

arts, household arts, and other sciences. The lists include all the articles needed for the problems outlined in this manual. For convenience in ordering supplies the articles are arranged alphabetically, and are numbered serially so that the teacher may, if desired, remove these sheets from the manual and send them to supply houses for estimates. The number in parentheses following the name of an article indicates the problem in which it is first used, thus referring the reader to the kind of use proposed for it. The approximate quantities needed are given, but teachers will often wish to change these quantities. Not all the articles listed are absolutely essential, but all will be found useful. The cost of the apparatus listed can be reduced about one third by omission of field glasses, compound microscope, small telescope, and incubator. When funds are limited, it is recommended that part of the apparatus be purchased each year until the equipment is adequate. At the most, the cost is but a few hundred dollars. Since prices fluctuate widely, however, they have not been included in this list, but may be secured from supply houses at the time when purchases are to be made.

PART I

A. GENERAL APPARATUS

ITEM	QUANTITY	NAME
1	1	Air pump (**1**)
2	1	Alcohol lamp (**6**)
3	2	Aquarium jar (**24**)
4	6	Balloons, rubber, toy (**4**)
5	1	Bell jar, $\frac{1}{2}$ gal., open at top (**4**)
6	2	Bunsen burner and 2 feet of rubber tubing (**6**)
7	4	Burette clamps (**1**)
8	2	Buzzers, electric (**47**)
9	1	Can, metal, nickel plated, 1 pint (**11**)
10	12	Candles, plumber's, large size (**16**)
11	3	Carbon rods, $\frac{3}{16}$ in. by 6 in. (**17**)
12	6	Clamps, special, for $\frac{5}{16}$-in. tube (**4**)
13	4	Compasses, 1 in. (**47**)
14	1 sq. ft.	Copper sheet, $\frac{1}{32}$-in. thick (**48**)
15	1 lb.	Copper wire, No. 18 D.C.C. (**4**)
16	$\frac{1}{2}$ lb.	Copper wire, No. 24 D.C.C. (**48**)
17	1	Cork borer, set of 6 (**6**)
18	1 doz.	Cork stopper to fit $\frac{1}{2}$-in. tube (**53**)
19	1 doz.	Cork stopper, No. 3 (**6**)
20	6	Dry cells (**17**)

Item	Quantity	Name
21	2	Electric bells (**47**)
22	1	Field glass (**49**)
23	500 sheets	Filter paper, 5 in. (**58**)
24	1	Flashlight (**44**)
25	12	Flower pots, 4 in. (**65**)
26	1	Hammer (**44**)
27	2	Hand lens (**23**)
28	1	Hoffman's apparatus for electrolysis (**17**)
29	12	Iron pans, 3 in. (**46**)
30	½ lb.	Iron wire, bare, No. 20 (**54**)
31	1	Locomotive model (**43**)
32	4	Magnets, 6-in. bar (**46**)
33	4	Magnets, U-form, 5 in. (**48**)
34	12 doz. boxes	Matches, safety (**6**)
35	1	Medicine dropper (**19**)
36	1	Meter stick, 100 cm. (**4**)
37	2	Meter sticks, 50 cm. long (**41**)
38	2 lb.	Mercury (**4**)
39	1	Microscope, compound (**23**)
40	100	Microscope slides and cover glasses (**23**)
41	1	Motor, St. Louis form (**48**)
42	1	Mortar and pestle, 3 in. (**60**)
43	6 doz.	Needles (**46**)
44	1	Osmometer (**57**)
45	6	Pinchcocks (**2**)
46	1	Pliers (**48**)
47	2	Pulleys, single (**41**)
48	6	Push buttons (**47**)
49	3	Ring stands, 3 rings (**1**)
50	3 sq. ft.	Rubber, sheet (**5**)
51	4 oz.	Rubber bands, assorted (**30**)
52	½ lb.	Rubber friction tape (**48**)
53	⅛ lb.	Rubber stopper, 1-hole, No. 1 (**6**)
54	⅛ lb.	Rubber stopper, 1-hole, to fit 2-liter bottle (**4**)
55	⅛ lb.	Rubber stopper, 1-hole, to fit 1000 cc. Pyrex flask (**4**)
56	¼ lb.	Rubber stopper, 2-hole, No. 5 (**1**)
57	¼ lb.	Rubber stopper, 2-hole, No. 7 (**2**)
58	¼ lb.	Rubber stopper, 2-hole, to fit open bell jar (**4**)
59	¼ lb.	Rubber stopper, 2-hole, to fit quart milk bottle (**17**)

Item	Quantity	Name
60	$\frac{1}{8}$ lb.	Rubber stopper, solid, to fit 6-in. side-neck test tube (**18**)
61	10 ft.	Rubber tubing, gum, $\frac{3}{16}$ in. (**1**)
62	10 ft.	Rubber tubing, heavy wall, $\frac{3}{16}$ in. (**4**)
63	2	Rulers, 1 ft., metric and English (**10**)
64	1	Scales, Cenco trip balance (**4**)
65	1	Screw driver, 6 in. (**48**)
66	1	Shears, metal, 9 in. (**44**)
67	1	Spring balance, 250 g. (**33**)
68	1	Spring balance, 2000 g. (**41**)
69	1	Stop watch (**42**)
70	2	Switches, battery (**17**)
71	1	Telescope (**49**)
72	1	Test-tube brush (**59**)
73	1	Test-tube holder (**16**)
74	1	Test-tube stand (**18**)
75	2	Thermometers, C. and F. scales. —10° C. to 110° C. (**9**)
76	1	Tripod with one ring (**54**)
77	1	Tweezers (forceps) (**18**)
78	1	Weights, metric, 1 g. to 1000 g. (**4**)
79	2	Wire gauze, 5 in. square (**8**)
80	2	Y-tubes, brass or iron (**4**)

B. GLASSWARE

81	12	Beakers, Pyrex, 100 cc. (**5**)
82	12	Beakers, Pyrex, 250 cc. (**9**)
83	2	Bottles, 2-liter (**4**)
84	6	Bottles, wide mouth, low form, 4 oz. (**5**)
85	12	Bottles, wide mouth, 6 oz. (**2**)
86	6	Calcium chloride tubes, 6 in. (**32**)
87	1	Cylinder, not graduated, 1000 cc. (**1**)
88	3	Dishes, crystallizing, 3 in. (**16**)
89	6	Flasks, Pyrex, 500 cc. (**8**)
90	2	Flasks, Pyrex, 1000 cc. (**4**)
91	2	Funnels, 3 in. (**60**)
92	1	Funnel, 6 in. (**24**)
93	5 lb.	Glass tubing, $\frac{3}{16}$ in., 5-foot lengths, two lengths of capillary tubing (**1, 48**)
94	3 lb.	Glass tubing, $\frac{1}{2}$ in. dia., 5-foot lengths (**53**)

Item	Quantity	Name
95	1 lb.	Glass tubing, capillary, $\frac{1}{4}$ mm. (10)
96	12	Glass plates, 2 in. square (15)
97	6	Glass plates, 8 in. square (25)
98	1	Graduate, 500 cc., graduated both up and down (4)
99	6	Petri dishes, 10 cm. in dia. (27)
100	12	Test tubes, 4 in. (5)
101	12	Test tubes, 6 in. (6)
102	12	Test tubes, 6 in., side-neck (18)
103	12	Test tubes, 8 in. (1)
104	2	Thistle tubes (5)

C. CHEMICALS

105	1 qt.	Alcohol, denatured (21)
106	1 lb.	Ammonium hydroxide, con. C.P. (15)
107	$\frac{1}{2}$ lb.	Beeswax (5)
108	12 blocks	Charcoal (18)
109	4 oz. each	Fehling's solutions A and B (59)
110	1 lb.	Hydrochloric acid, con. C.P. (18)
111	100 cc.	Iodine solution (20)
112	2 lb.	Iron filings (46)
113	$\frac{1}{2}$ lb.	(Limewater) calcium oxide, in tin (16)
114	1 lb.	Marble, small pieces (18)
115	1 lb.	Nitric acid, con. C.P. (59)
116	1 lb.	Paraffin (5)
117	$\frac{1}{2}$ lb.	Potassium nitrate (7)
118	1 lb.	Sulfuric acid, con. C.P. (17)
119	1 lb.	Sodium hydroxide, sticks (19)
120	1 lb.	Sodium peroxide (19)
121	1 lb.	Zinc, granulated (19)

Part II

MISCELLANEOUS ITEMS WHICH MAY BE SECURED FROM VARIOUS SOURCES

Item	Quantity	Name
122	1	Apple corer (57)
123	$\frac{1}{2}$ lb.	Barley (60)
124	$\frac{1}{2}$ lb.	Beans (65)
125	$\frac{1}{2}$ lb.	Bread (25)

Item	Quantity	Name
126	12	Candles, small, $\frac{1}{2}$ in. (**18**)
127	4 sq. ft.	Cardboard, heavy, white (**12**)
128	6	Carrots, large (**57**)
129	5 lb.	Coal, hard (**33**)
130	$\frac{1}{4}$ lb.	Clover seed (**58**)
131	6	Corn, large ears (**66**)
132	$\frac{1}{4}$ lb.	Corn, shelled (**59**)
133	1 qt.	Corn sirup (**26**)
134	$\frac{1}{2}$ lb.	Cotton, absorbent (**30**)
135	1 quire	Cross-section paper (16 in. by 22 in.) $\frac{1}{8}$-in. squares (**13**)
136	1 quire	Cross-section paper, metric (8 in. by 10 in.) (**28**)
137	24	Eggs (**64**)
138	1	Fan, palm-leaf (**30**)
139	1	Fire extinguisher (**18**)
140	2 doz.	Frogs' eggs (**63**)
141	1 gal.	Gasoline (**33**)
142	6	Gelatin plates (**27**)
143	3	Geranium plants, in pots (**20**)
144	1	Globe, black, 12 in. (**14**)
145	5 lb.	Ice (**9**)
146	1	Incubator (**64**)
147	1 qt.	Ink, blue-black (**8**)
148	2 lb.	Iron, scrap, in small pieces (**33**)
149	1 gal.	Kerosene (**33**)
150	6	Lamp bulbs, any size (**3**)
151	2	Lily plants (or iris, Wandering Jew, corn, live-forever, etc.) (**23**)
152	3	Milk bottles, quart size (**17**)
153	1	*Monthly Evening Sky Map*, for the months used (**50**)
154	1 oz.	Mustard seed (**58**)
155	1 lb.	Nails, large spikes (**47**)
156	1 pint	Paste, library (**16**)
157	$\frac{1}{2}$ lb.	Peanuts, not roasted (**65**)
158	1 roll	Picture wire (**19**)
159	12 doz.	Pins (**48**)
160	4	Plants, in pots (coleus or geranium) (**31**)
161	1 lb.	Potato (**20**)
162	12 sticks	"Punk," or any other slow-burning, smoking substance (**7**)

ITEM	QUANTITY	NAME
163	6	Quart fruit jar (57)
164	1 oz.	Radish seeds (58)
165	1	Razor (23)
166	1 pint	Red ink (58)
167	¼ lb.	Rice (59)
168	5 lb.	Salt (11)
169	10 lb.	Sand, white (65)
170	1 lb.	Sawdust (8)
171	6	Soil samples, 1 qt. each (52)
172	6	Spoons, large, cheap variety (54)
173	1	Star and planet finder (50)
174	½ lb.	Starch (20)
175	5 lb.	Stone, various samples (33)
176	1 lb.	String, white, cotton warp (12)
177	2 lb.	Sugar (59)
178	2 doz.	Thumb tacks (12)
179	6	Towels, hand (11)
180	1 jar	Vaseline (61)
181	1	Ventilation box (homemade) (7)
182	1 lb.	Wheat (59)
183	1	Wood rod, 3 ft. long, ¼ in. dia. (1)
184	1 bundle	Wood splints (18)
185	1 cake	Yeast (26)

Caldwell, O.W. 621487

Elements of general science.

NAME	DATE	NAME	DATE
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